Technology Review

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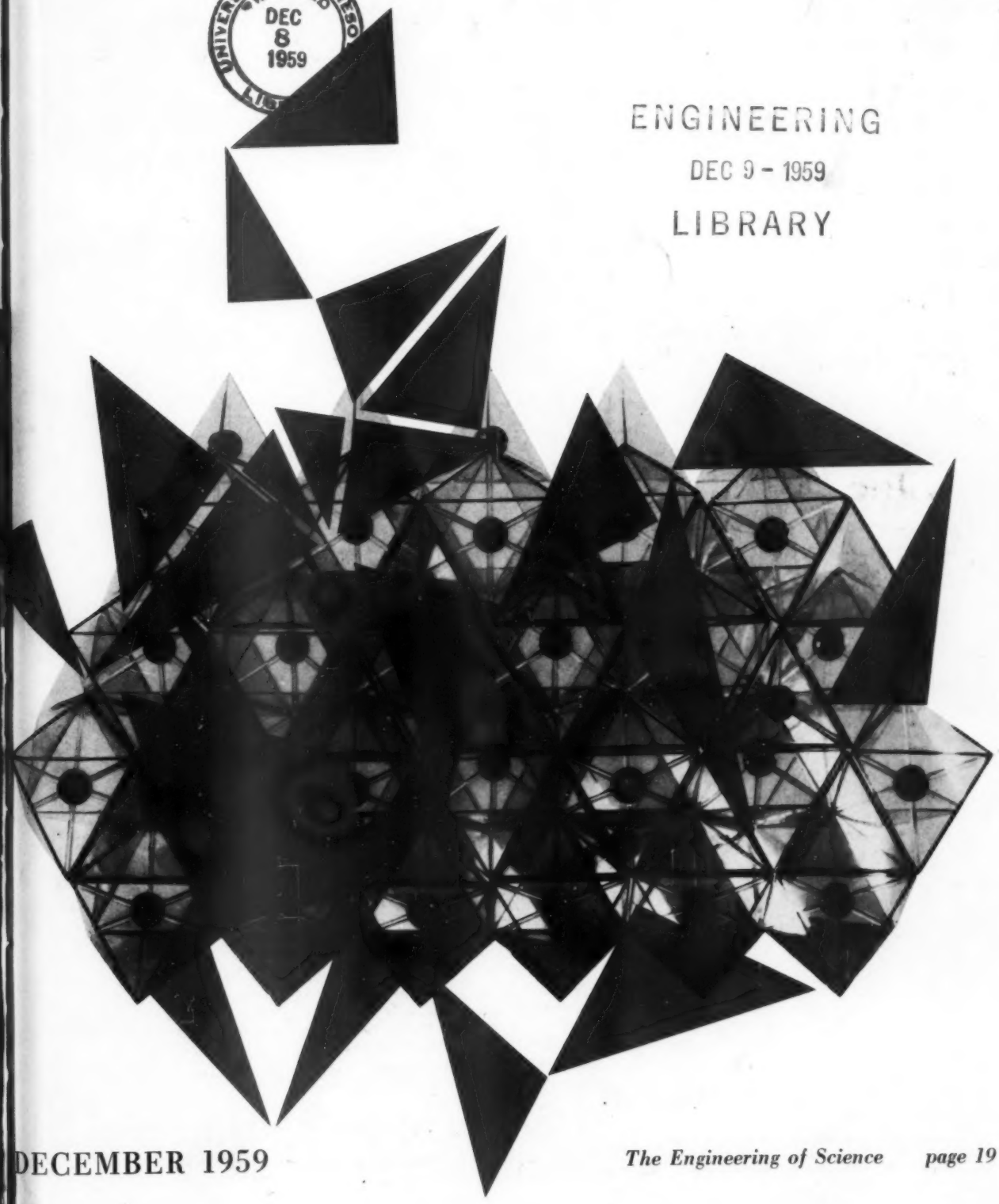

"CREATIVE ENGINEERING" BRINGS BIG ECONOMIES TO WIDE-SCALE HEATING

Nation's largest High Temperature Water installation heats U.S. Air Force Academy

The year 1959 marks a milestone in the history of The United States Air Force—the year in which members of the first graduating class at the U. S. Air Force Academy earned their commissions.

Situated in the Rampart Range of the Rockies north of Colorado Springs, on a 28-square-mile site, the new academy incorporates many notable advances in design and engineering. For example, the heating system which services the widely-spaced buildings utilizes *high temperature water*. This system, compared to steam, frequently offers important advantages for large-scale heating. Since hot water has an inherently higher capacity to contain heat, it not only reduces initial equipment costs, but also makes possible operating and maintenance savings of from 10% to 20%. Smaller-sized pipes can also be used, steam traps and pressure valves are eliminated, and the boiler plant can be smaller—more compact than required by steam—with greater operating control and efficiency.

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Volume 62, Number 2 *Edited at the Massachusetts Institute of Technology* *December, 1959*

Feedback

Names in Class Notes

FROM RICHARD W. WILLARD, '51:

Provided costs are not prohibitive, I propose the format of the Class Notes be changed so that all names of Alumni appear in boldface. When I prepare a set of Class Notes under the present system, I find myself trying to begin sentences making reference to an alumnus with his name. Were boldface type used for names I would not feel I must have this concern.

As a reader of notes for classes other than mine, I am sure readers would prefer the boldface. I know only part of the Alumni in other classes (and in my own, too), so I am mainly interested as a reader in finding references to those whom I know.

Boldface names would make is obvious that Class Notes are short notes about people. The present format implies that the notes are essays. I am one writer of Class Notes who believes in the former, and who shudders if my notes are considered the latter.

M.I.T., Cambridge, Mass.

(The costs would be higher, but not prohibitive. Some class secretaries have objected to the proposal—ED.)

A Roof for the Rink

FROM SIDNEY ALTMAN, '60:

With the recent completion of the Du Pont Athletic Center, I, speaking in behalf of the present varsity hockey team, wish to bring to the eye of the M.I.T. community and Alumni another project for which there is sore need. That is, construction of a roof over, or enclosure about, the present ice-skating surface.

During the last few years, the ability of the M.I.T. hockey teams to field competent squads has steadily declined because of poor practice facilities in contrast with improving facilities at other schools. Our practice time is cut by snowfalls and the often adverse weather in Boston. But this is not our only reason for wanting action regarding the rink. Throughout the community there are people who express a desire to see hockey games, but are deterred by the thought of standing in the cold for two or three hours. At other schools we visit, the hockey arena is a central meeting place on the campus when games are scheduled. At our school, a group of 30 people is considered a good turnout.

M.I.T., Cambridge, Mass.

ELTING E. MORISON, Professor of History at M.I.T. since 1946, prepared a memorable paper for a Sloan Fellows' convocation, a part of which became the article on page 31 this month.

EDITOR: Volta Torrey; BUSINESS MANAGER: R. T. Jope; CIRCULATION MANAGER: D. P. Severance; EDITORIAL ASSOCIATES: J. J. Rowlands, Francis E. Wylie, John I. Mattill; EDITORIAL STAFF: Ruth King, Diana de Filippi; BUSINESS STAFF: Madeline R. McCormick, Louise E. Ryan; PUBLISHER: H. E. Lobdell.

The Technology Review is published monthly from November to July inclusive, on the 27th day of the month preceding the date of issue, by the Alumni Association of M.I.T.; Edward J. Hanley, President; H. E. Lobdell, Executive Vice-president; William W. Garth, Jr., William L. Taggart, Jr., Vice-presidents; Donald P. Severance, Secretary-Treasurer.

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Editorial and business offices are in Room 1-281, Massachusetts Institute of Technology, Cambridge 39, Mass. The Review is published at Hildreth Press, Inc., Emmett Street, Bristol, Conn.

An annual subscription in the U.S. is $4.00; in Canada and elsewhere, $4.50; a single copy, 60 cents. Three weeks must be allowed to effect a change of address, for which both the old and the new address should be given.

Entered as second-class matter December 23, 1949, at the Post Office, at Bristol, Conn., under the Act of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925.

This Month — *The Cover*

The photograph that was the basis of this month's cover shows some of the interstitial crystal models invented by Prof. A. L. Loeb and I. L. Morris of the Computer Components and Systems Group which are now used as a teaching aid in the Department of Electrical Engineering. With four different modules (octahedra filled, octahedra empty, tetrahedra filled, and tetrahedra empty), three-dimensional models of lattices found in a wide variety of crystals can be assembled.

Individuals Noteworthy **4**

Benjamin S. Kelsey, '28, becomes Hunsaker Professor of Aeronautical Engineering . . . other news of the staff and Alumni of M.I.T.

The Trend of Affairs **15**

The Ford Foundation announces its plans to devote $19,050,000 to an effort to advance a renaissance in engineering education.

The Engineering of Science **19**

Dean Gordon S. Brown describes the program made possible by the $9,275,000 grant to M.I.T. from the Ford Foundation this fall.

M.I.T. Studies My Bones **23**

A Reading, Pa., school teacher describes the work of the M.I.T. Radioactivity Center which she and many others are assisting.

Books **26**

Prof. Norbert Wiener's novel and illustrations by Henry Kane for John Kieran's new book are featured.

How Do We Learn Math? **28**

Prof. Robert B. Davis of Syracuse University reports progress in a fascinating study of who learns mathematics, how, and why.

Pertinence of the Past **31**

Prof. Elting E. Morison discusses the affections in the time of the computer.

Talk of Our Times **50**

Some remarks on architecture by Edward D. Stone, '27.

Institute Yesteryears **52**

Items that were news 25, 50, 75 and 100 years ago at M.I.T.

Individuals Noteworthy

Aeronautics' Visitor

THE visiting Jerome Clarke Hunsaker Professor of Aeronautical Engineering at M.I.T. this year is Brigadier General Benjamin S. Kelsey, '28, who retired from active duty in the U. S. Air Force in 1955 and has since been a consultant to industrial organizations. He will give the Minta Martin lecture on aviation next March.

General Kelsey became a test pilot for the U. S. Army Air Corps in 1929, and was attached to the Guggenheim Fog Flying Laboratory where work was done on instrument landing. He was in charge of fighter procurement and production projects at Wright Field from 1934 to 1943, and took part in the first trans-Atlantic ferry flights of the P-38's and 22 combat missions for the Eighth Air Force. Later, he was on the faculty of the National War College and Deputy Director for Research and Development at USAF headquarters in Washington.

He holds the Distinguished Service Medal, Distinguished Flying Cross, Legion of Merit and Air Medal, and the Institute of the Aeronautical Science's 1945 Octave Chanute Award.

Naval Commander

CAPTAIN George L. Street, 3d, of the U.S. Navy became Professor of Naval Science at M.I.T. this fall and took command of the Naval R.O.T.C. Unit and the Naval Administrative Unit. Captain Street participated in the recent Lebanese crisis as commander of the Attack Transport *U.S.S. Fremont* (APA 44). Under his command in World War II, the submarine *U.S.S. Tirante* penetrated Japanese harbors while surfaced and sank a number of enemy craft. He holds the Congressional Medal of Honor, the Presidential Unit Citation, the Navy Cross, the Silver Star, a Gold Star and the Submarine Combat Insignia.

He was graduated from the U.S. Naval Academy in 1937, served on the faculty of the Armed Forces Staff College from 1948 to 1951, and was graduated from the National War College in 1956 after a year's study of international affairs.

Benjamin S. Kelsey

Honors to Alumni

RECENT recipients of medals and other honors have included:

Henry C. Harrison, '13, the Elliott Cresson Medal, from The Franklin Institute . . . *Augustus B. Kinzel, '21,* the Industrial Research Institute Medal for 1960 . . . *Walter Edward Campbell, '26,* the grade of fellow in the American Institute of Architects . . . *Charles Kingsley, Jr., '27,* the grade of fellow in the American Institute of Electrical Engineers;

Gordon S. Brown, '31, the electrical engineering education medal of the American Institute of Electrical Engineers . . . *Brig. Gen. John L. Person, '32,* the Distinguished Service Medal awarded by President Eisenhower . . . *Morris Cohen, '33,* the Francis J. Clamer Medal, from The Franklin Institute . . . *Capt. Loren E. Brunner, '41,* the Legion of Merit by the U. S. Treasury Department;

Randall D. Esten, '45, a second Sustained Superior Performance Award by the U. S. Army Engineer Research and Development Laboratories . . . *Harold G. Ingraham, Jr., '49,* the grade of fellow by the Society of Actuaries . . . *Edward R. Hermann, '49,* the Eddy award of the Federation of Sewage and Industrial Wastes Association . . . *Milton Stern, '50,* the 1958 prize to young authors by the Electrochemical Society . . . *John Dahlen, '52,* the Air Force Commendation Medal . . . *John Musho, '59,* the 1959 Rome Prize for a student of architecture.

Liaison Officers

JOHN F. MAXWELL, JR., '52, and Gary L. Benton, '59, have been appointed Industrial Liaison Officers at M.I.T. Mr. Maxwell, a graduate of the Amos Tuck School of Business Administration at Dartmouth, previously worked with the Northwest Paper Company, the Safe Harbor Water Power Corporation, and the Convair Division of General Dynamics. Mr. Benton, a Carnegie Institute of Technology graduate, held a Whitney Fellowship in the Graduate School at M.I.T. and was a Research Assistant in the Industrial Dynamics Group of the School of Industrial Management.

They succeed Robert D. Haberstroh, '51, who has joined the faculty of Colorado State University, and Merrill J. Baumann, '52, who is now with Merrill, Lynch, Fenner and Smith.

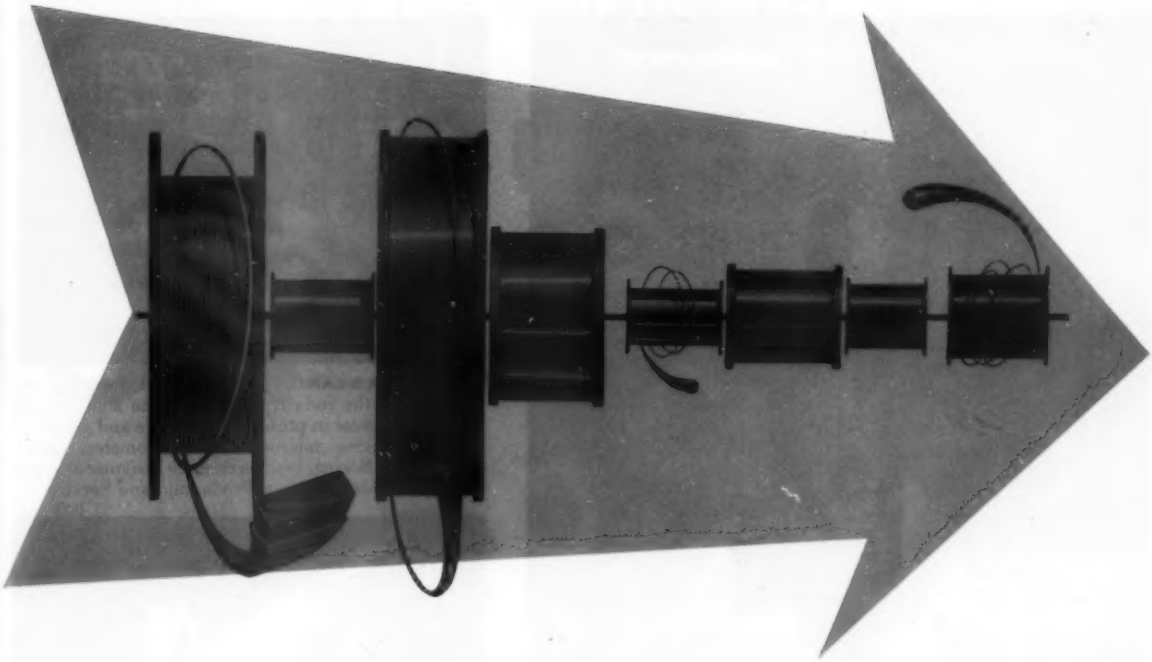
Personnel Relations Director

ROBERT J. DAVIS, who has been responsible for all M.I.T. union relations since 1957, became director of the Office of Personnel Relations in August. Mr. Davis came to M.I.T. from the Atomic Energy Commission in 1956 to be director of union relations at Lincoln Laboratory.

Previously he had been personnel director for the Los Alamos Scientific Laboratory, associated with the Columbia Steel Company, the Kaiser Steel Company, and the American Potash and Chemical Corporation, and in the U.S. Navy. He was graduated in 1937 from the Virginia Polytechnic Institute.

In his new post, he succeeds Malcolm G. Kispert, '44, Administrative Vice Chancellor, to whom he will report.

(Continued on page 8)



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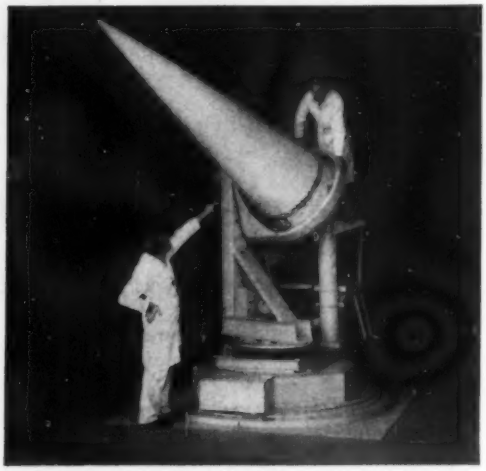

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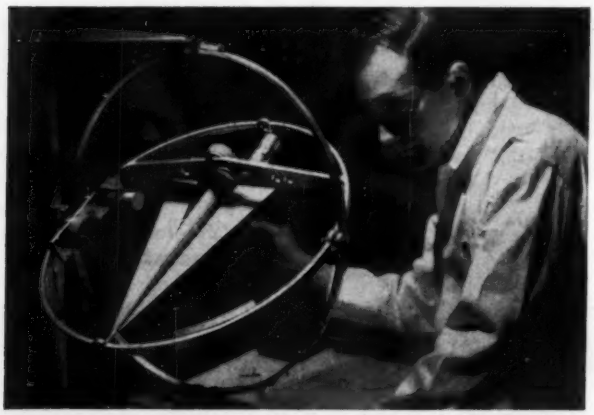

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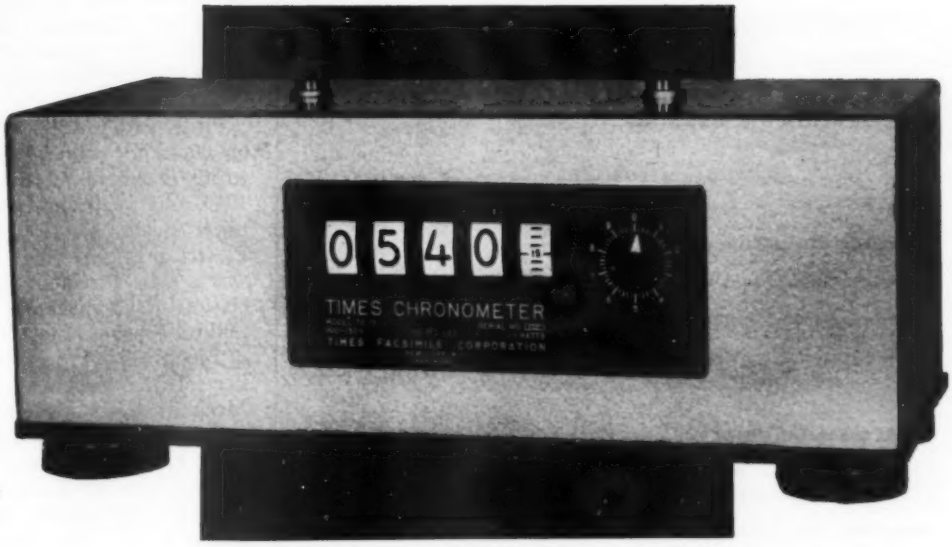

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Individuals Noteworthy

(Continued from page 4)

W. H. Timbie: 1877–1959

PROFESSOR EMERITUS William Henry Timbie died on October 30 in Brattleboro, Vt. He was largely responsible for establishing the Electrical Engineering Cooperative Course (VI-A) at M.I.T., and headed it for 28 years prior to his retirement in 1947.

Professor Timbie was born in Pittsfield, Mass., and graduated from Williams College. He taught electrical engineering for nine years at the Pratt Institute in Brooklyn, N. Y., and for seven years at the Wentworth Institute in Boston, where he was head of the Department of Applied Science. During World War I, he was editor-in-chief of the Committee on Education and Special Training in the War Department. He came to M.I.T. in 1919 as Associate Professor of Electrical Engineering, and in 1923 became Professor of Electrical Engineering and Industrial Practice.

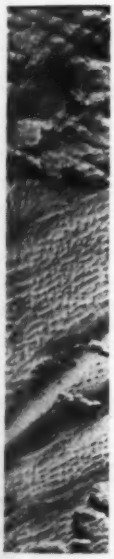
Professor Timbie was the author or co-author of eight books; he wrote "Elements of Electricity" in 1910, and was co-author with Vannevar Bush, '16, of "Principles of Electrical Engineering" in 1922. He was a past president of the Association of Cooperative Colleges, a Fellow of the American Institute of Electrical Engineers, and a member of the American Society of Mechanical Engineers, the American Society for Engineering Education, Phi Beta Kappa, Kappa Eta Kappa, and Pi Gamma Mu. He lived most of his life at 295 Highland Avenue, West Newton.

Professor Timbie is survived by his wife, Florence Hill Timbie; three sons, Charles, of Framingham, Robert, of Pensacola, Fla., and Theodore, of Marblehead; and two daughters, Mrs. Florence Steinkamp of Marshfield, Wis., and Mrs. Francis Vachon of Portland, Maine.

Recording Secretary

TO ACCOUNT properly for the variety of gifts and bequests that M.I.T. receives through many different offices, Frederick W. Watriss, '41, has been appointed Recording Secretary. He is Assistant Treasurer.

(Continued on page 10)



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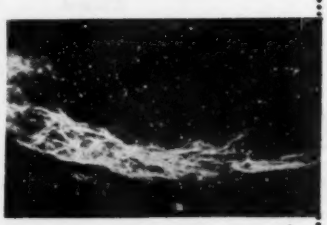

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Individuals Noteworthy

(Continued from page 8)

In the News . . .

HIS IMPERIAL HIGHNESS *Merid Asmatch Asfa Wossen,* Crown Prince of Ethiopia and son of Haile Selassie, toured M.I.T. this fall. He is a direct descendant of King Solomon and the Queen of Sheba. Princess Medseriash War Abebe accompanied him. . . . *Roger Babson, '98,* who predicted the 1929 Wall Street crash, told the press this fall that he sees some similarities between the situation then and now, but doesn't expect another crash. He said he was advising clients to have $7 in cash or bonds for every $3 in stocks, because he expected an erosion in stock prices but the market might rise and the $3 was a hedge. . . . *Mrs. Karl Taylor Compton* saw the cornerstone laid at Israel Institute of Technology for a building bearing her late husband's name. . . . *John Scali, '40,* Associate Professor of Civil Engineering at Case Institute of Technology, heads a research team studying the loads on people's feet, to aid orthopedic surgeons. . . . *Bruce Shore,* a graduate student, has organized a water polo team at M.I.T.

(Continued on page 36)

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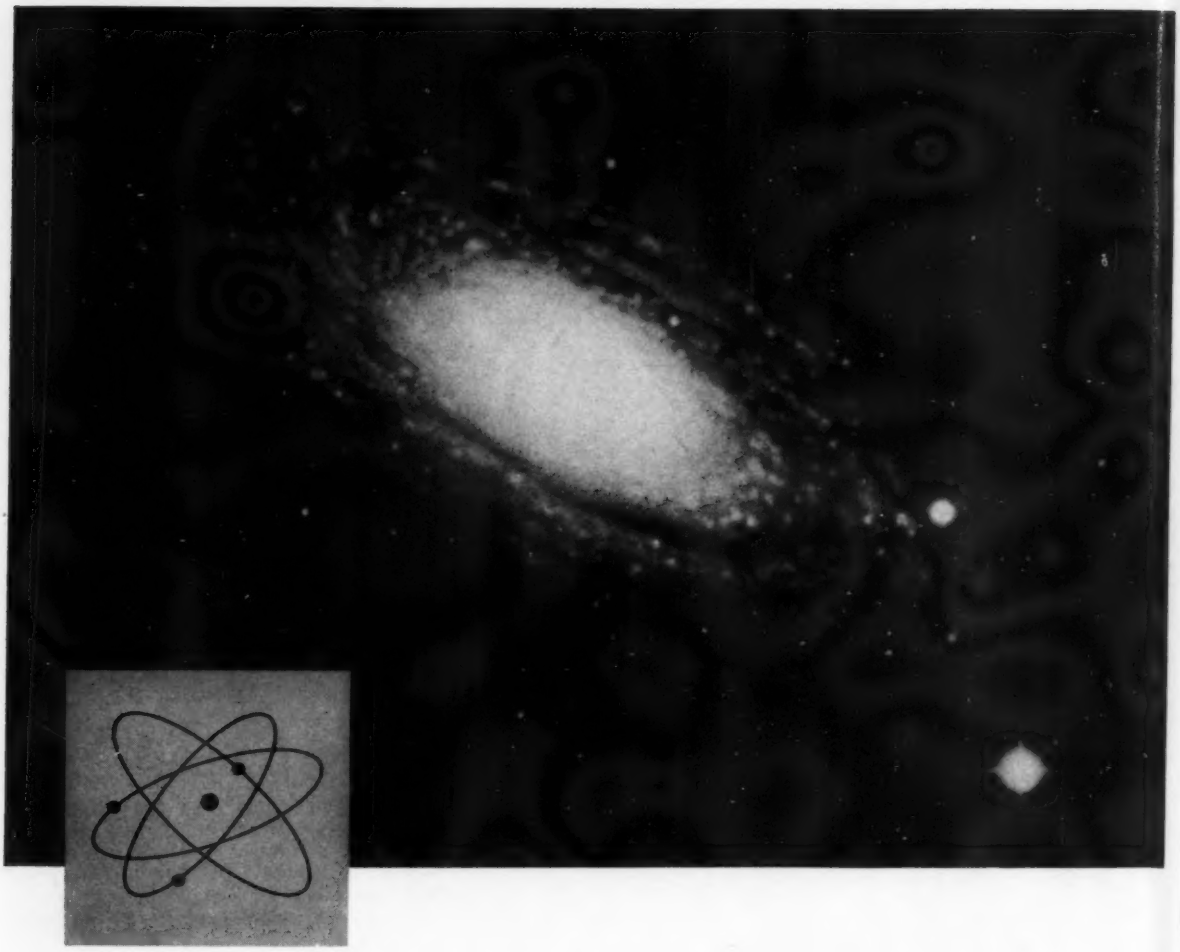

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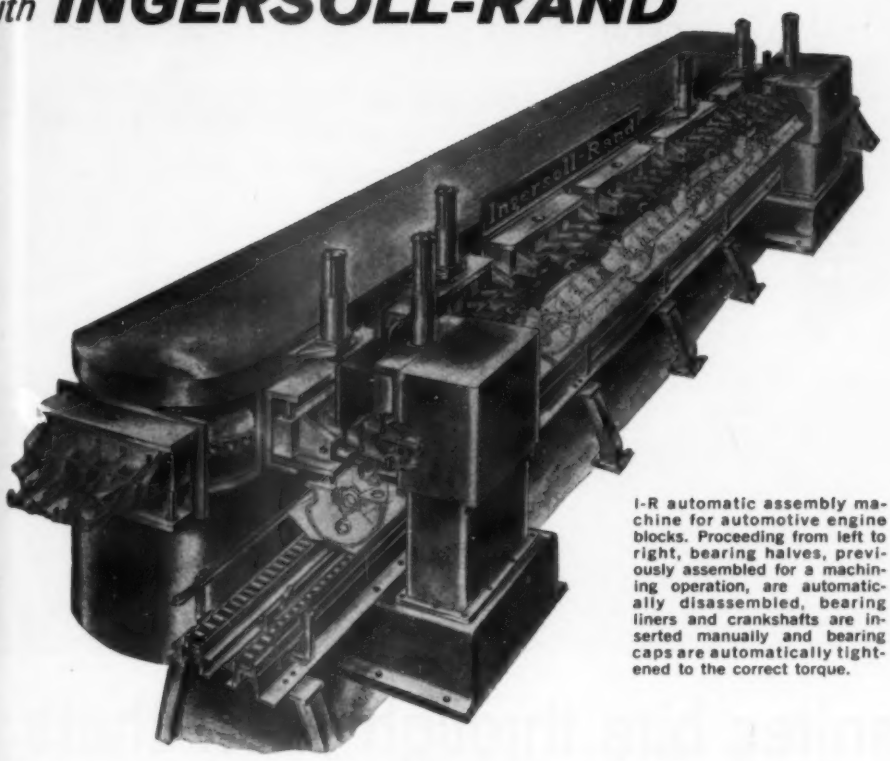

I-R automatic assembly machine for automotive engine blocks. Proceeding from left to right, bearing halves, previously assembled for a machining operation, are automatically disassembled, bearing liners and crankshafts are inserted manually and bearing caps are automatically tightened to the correct torque.

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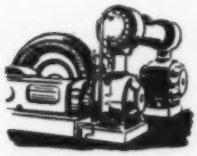
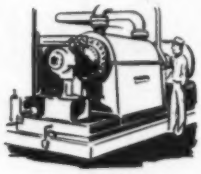


Compressors and Blowers



Centrifugal Pumps

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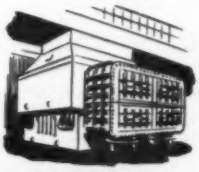
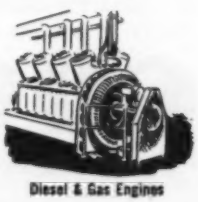


Steam Condensers



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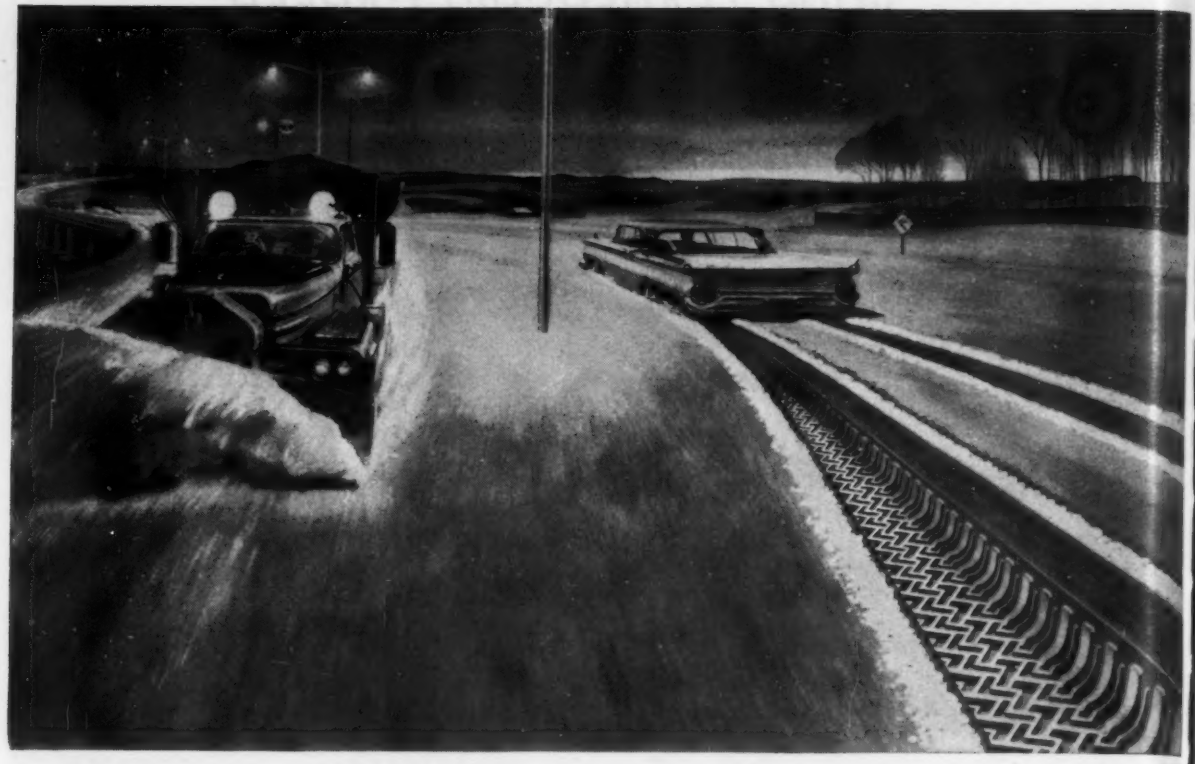

Suburbanites bite through snow that's HUB-CAP DEEP!

• **New! Exclusive Goodyear tread grip**—for 51% more traction in snow, 17% more traction in mud!

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SUBURBANITES by Goodyear have been tested way up in Canada's Hudson Bay area. And they've also proved their stuff where *you* drive—from driveway to superhighway.

In snow or mud, Suburbanites give you DYNAMIC TRACTION . . . *extra grip under power* from 3,728 biting edges on 260 massive tread cleats! Suburbanites *go*.

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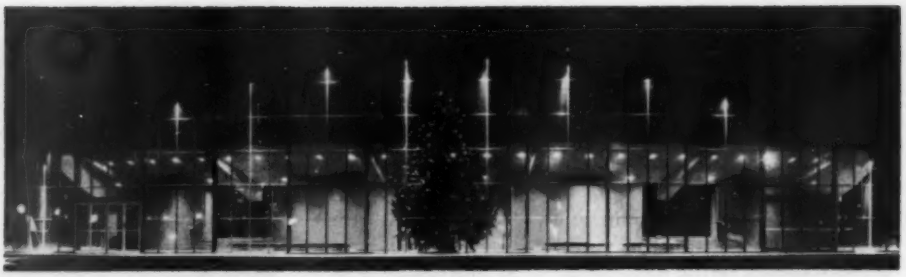
Watch the award-winning "Goodyear Theater" on TV every other Monday evening. Suburbanite, T.M., The Goodyear Tire & Rubber Company, Akron, Ohio

Trend Of Affairs



Funds for a Renaissance In Engineering Education

TEN YEARS AGO, when the Ford Foundation began surveying ways in which its funds might be used most effectively, the great social problems seemed to cry for priority over science and engineering and no assistance was given to the latter. Four years ago, however, after the bearing of science and engineering on human welfare had become clearer to everyone, the foundation began to plan a program to support these activities, and this fall President Henry T. Heald of the foundation announced that grants totaling $19,050,000 were being made to 10 institutions to improve engineering education.

The largest of these grants, amounting to $9,275,000, was given to the Massachusetts Institute of Technology. It was the largest single gift that the foundation ever had made to a college or university. At the same time, the California Institute of Technology received $3,200,000; the Carnegie Institute of Technology, $2,250,000; the University of California at Los Angeles, $1,200,000; the University of Michigan, $1,175,000; Case Institute of Technology, $1,000,000; the University of Illinois, $275,000; Purdue University, $275,000; Stanford University, $200,000, and the University of Wisconsin, $200,000.

Mr. Heald listed these grants in an address at a meeting in Washington of the American Institute of Consulting Engineers. He said then, in part:

"In the last two decades, a revolution has been under way in the practice of engineering. Although it is more dramatic in electronics and aeronautical engineering than in civil engineering, the nature of the change is such that it affects everyone who professes to the calling of engineer.

"If the engineer is still concerned about his professional status, I can think of no surer way to allay such fears than by exceptional performance. Unusual opportunities for exceptional performance now exist through a thorough and deep understanding of science and mathematics, their frontiers, and how they may be applied to the needs of mankind.

"However, many of the important engineering achievements of recent years have been wrought by scientists applying their own discoveries. This does not mean that the engineer is about to become as obsolete as the trolley conductor, or that his numbers will decline as radically as the farmer's.

"Quite the contrary. Because engineering is more closely allied to scientific principles, because the span between discovery and application has been greatly compressed, and because the new technology is more complex and costlier, the unique talents and discipline of the engineer are more in demand than ever.

"Yet engineering education – the gateway to professional practice – has lagged behind the revolution in technology. In a hopeless race against time and reality, most engineering students in their late teens and early twenties are being equipped for the engineering of the last half of the twentieth century by being indoctrinated with the art and practice of the 1950's.

"It is a paradox that as engineering opportunities have expanded greatly, enrollments have risen only slightly and, in several postwar years, actually declined. I suggest that the inertia of engineering education is one of the major factors in the failure of engineering to attract vastly increased numbers of students.

"Unless this trend is reversed, the technological future of the United States is in grave peril."

Mr. Heald went on to speak of the weakness of engineering education "in quality as well as in a sheer deficiency of numbers," and to explain that the foundation's grants were intended to support imaginative programs now under way in some schools, to expand the influence of these ventures, and to encourage new attempts to renovate the preparation of engineers.

Since "the most ingenious designs for education are hollow without comparably broad and imaginative faculties," he said, emphasis has been placed in the grants on strengthening present faculties and recruiting additional engineering teachers. But the grants also include provisions to accelerate curriculum modernization and new educational experiments. "These include," he said, "a curriculum focused on science-based core courses that cut across traditional departmental lines, emphasis on the concept of design as a discipline basic to engineering education, and the widespread use of high-speed computers to enrich classroom instruction."

Mr. Heald concluded his remarks by reminding his audience of consulting engineers:

"Even if this program should exceed our expectations, no single foundation can hope to constitute the sustaining force in so vital an enterprise as engineer-

ing education. The responsibility for long-term enrichment of engineering education rests on the engineering schools, on the engineering profession, on parents, and all of society.

"You gentlemen can make notable contributions to a renaissance of engineering education, for you function wide of professional ruts, you are influential alumni of engineering colleges, and not only have you achieved distinction in your specialties but you have also dealt with broad public issues and have an understanding of the social uses — and limitations — of engineering.

"Engineering education needs your support and the benefit of your experience. It may even need you as teachers. But perhaps the most important role you can play is to carry your professional life to higher levels, to apply the new technology, with its treasure of science and mathematics, to present engineering problems, the seemingly prosaic as well as the exotic, no matter how embedded in tradition their solutions are.

"The challenges and the opportunities are limitless. As you grasp them, the engineering profession will be honored in society not for past accomplishments but for extraordinary contributions to the present and time to come."

Details of the grant to M.I.T., and the aspirations of the Institute's School of Engineering, are explained by Dean Gordon S. Brown, '31, in the article entitled "The Engineering of Science" on page 19.

Seven other universities received grants to strengthen their faculties, and four, in addition to M.I.T., received grants intended either to accelerate curriculum modernization plans now under way or to undertake new educational experiments. The University of California at Los Angeles, for example, will concentrate on the concept of design as a discipline basic to engineering education, and the University of Michigan will experiment with the use of computers to enrich classroom instruction.

President Stratton's Statement

THE INSTITUTE'S gratitude for the $9,275,000 grant from the Ford Foundation was expressed by President Julius A. Stratton, '23, in these words:

"We are deeply grateful to the Ford Foundation for this truly magnificent grant, which will enable M.I.T. to take one of several highly important steps we hope to make in the years just ahead through a major development program.

"The accelerating tempo of the world's technological change imposes great demands on engineers and it has become increasingly clear that the strengthening of engineering education is a major national goal. With the funds from the Ford Foundation, we can begin to meet these challenges with an imaginative and venturous spirit.

"I am confident that the advances planned for the School of Engineering at M.I.T. will be reflected importantly in the technology of the world in years to come. And since technological developments inevitably produce far-reaching changes in society itself, I am equally confident that the program we envision will make profound contributions to the common good."

A NEW CERAMIC that transmits light, withstands high temperatures, and can be pressed into any shape desired, was first made by Robert L. Coble, '55 (above), of the General Electric Research Laboratory. It is made from powdered aluminum oxide. Edward R. Stover, '50, was one of the men who contributed to its development, and J. Herbert Hollomon, '40, foresees many uses for it. This ceramic, Dr. Hollomon has pointed out, "illustrates our ability to create entirely new materials when we gain better understanding of fundamental scientific processes."

Uncle Dudley's Reaction

THE GRANT to M.I.T. by the Ford Foundation prompted the Boston *Globe's* "Uncle Dudley" to comment on "M.I.T.'s New Opportunity" in this vein:

"That the future will depend largely on the country's engineers is universally recognized. . . . The engineer has a way of winning public confidence. He is at once skilled and practical. His achievements are plain to see. In high public positions he is often useful and constructive. But in the face of unusual conditions he sometimes lacks sufficient boldness and imagination.

"An engineer officer, George B. McClellan, trained the Union Army of the American Civil War into an effective combat instrument. But he was fatally overcautious as a field commander.

"A 'great engineer' was the label accorded Herbert Hoover when he ran for office. He has made lasting contributions to American government and administration. But he was denied reelection as President because of the great depression. His critics among historians say that he made many of the right moves to meet that crisis, but failed to develop them boldly enough.

"That engineering education has always discounted imaginative thinking there is considerable reason to

FOR "WHO'S WHO," Warren K. Lewis, '05, described his career tersely: "With Mass. Inst. Tech., 1910–, prof. chem. engring., 1915–48." His achievements could fill columns. Students are still enjoying his anecdotes, and Professor Lewis is planning a book about social and economic implications of engineering. Robert C. Lyon of the M.I.T. Photo Service made this portrait of chemical engineering's father in his office this fall, shortly before Dr. and Mrs. Lewis left to celebrate their 50th wedding anniversary with four children and their families.

believe. Nearly three-quarters of a century ago two Massachusetts Institute of Technology undergraduates asked a professor friend whether they had a chance of succeeding in the electrical business. He replied that there might be room for one of them, but not for both. They went ahead anyway and founded one of the largest concerns in the country. . . .

"Institutions that teach engineering have begun to recognize the defects of their qualities. Several years ago M.I.T. established a compulsory course in the humanities. Perhaps in recognition of the spirit that impelled this move, the Ford Foundation has made the Institute the chief beneficiary of the first major grants in its new program in science and engineering. . . .

"That immense sums will be spent to modernize engineering education is heartening. To keep it looking forward has always been a problem and always will be. For that very reason, the Foundation would be wise to make future grants with the broadening of opportunity as at least one of its aims. . . .

"The Ford Motor Company, it is worth recalling, stems from a man who was trained on the job as a machinist. His friend, Thomas Edison, had little formal education. To assure American engineering the venturesome spirit that is essential, the way should be kept open for geniuses like these."

The Treasurer's Report

LAST YEAR'S changes in the Institute's financial affairs were summarized as follows in the report of Joseph J. Snyder, 2-44, Vice-president and Treasurer, to the Corporation this fall:

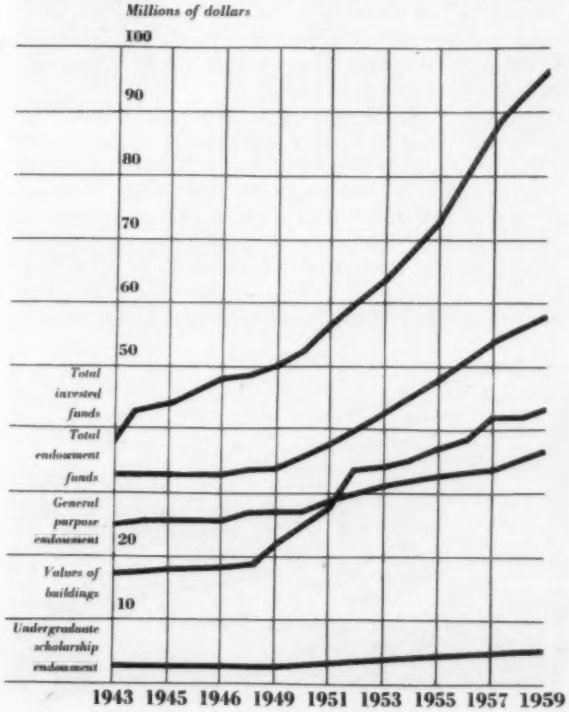
	1958-59	1957-58	Increase
Academic operations	$23,125,000	$20,905,000	$2,220,000
Sponsored Research	59,627,000	54,344,000	5,283,000
Total funds	99,142,000	91,773,000	7,369,000
Plant assets	44,179,000	43,251,000	928,000
Gifts and grants	10,006,000	7,732,000	2,274,000
Investments:			
Market value	155,777,000	132,150,000	23,627,000
Book value	97,865,000	89,267,000	8,598,000

Operations in 1958-59 and the previous year were compared in this table:

Revenues and funds	**1958-59**	**1957-58**
Tuition and other income	$7,667,000	$6,485,000
Investment income	1,722,000	1,913,000
Gifts and other receipts	5,344,000	4,481,000
Contract allowances for indirect expenses	6,543,000	6,211,000
Auxiliary activities	1,849,000	1,815,000
Total	$23,125,000	$20,905,000
Expenses		
Academic	9,816,000	8,718,000
General and administration	7,895,000	7,149,000
Plant operations	3,537,000	3,210,000
Auxiliary activities	1,877,000	1,828,000
Total	$23,125,000	$20,905,000

The rate of income earned in 1958-59 on the funds sharing in the general investments was 6.22 per cent on the average book value.

THE GROWTH OF M.I.T.'S FUNDS AND PLANT



Radioactive Waste Disposal

BY 1980, the nuclear power industry expects its installed capacity to total 175,000,000 kilowatts. The radioactivity of the waste products of such an industry, even after a year of storage, will be about 100,000,000,000 curies a year – and the maximum permissible concentration of mixed radioisotopes in water is only 1/10,000,000,000th of a curie per liter. The great seas which have received much of mankind's waste could not accept this many curies annually without being significantly affected. How is public health going to be safeguarded?

The problem is so grave that the International Atomic Energy Agency will devote large sums of money, for years to come, in many parts of the world, to research regarding radioactive waste disposal. To plan this great program, it turned to M.I.T., and summoned Prof. Rolf Eliassen, '32, of the Department of Civil and Sanitary Engineering, to its headquarters in Vienna for a month this fall. While overseas, Professor Eliassen also was scheduled to participate in an international conference at Monaco on disposal of radioactive waste, which was co-sponsored by the International Atomic Energy Agency and the United Nations Educational, Scientific and Cultural Organization.

Magnetic Calculations

SEVENTY-SIX complex and voluminous calculations, which would have taken hundreds of years by pencil and paper, have been processed through an M.I.T. computer to obtain a better understanding of a group of atoms that hold increasing interest in science and engineering. This mathematical spadework, left undone until now despite other advances in atomic research, represents a step forward in studies of the magnetism and energies of the "iron series elements." Some of these are the working materials in recent devices such as magnetic amplifiers, masers, and computer memory cores.

The iron series elements – scandium, titanium, vanadium, chromium, manganese, iron, cobalt, and nickel – have a group of so-called "3d" electrons which are the source of their magnetic properties. Electrons in most atoms are paired so that the magnetism of one counteracts that of a second. Atoms of the iron series, however, have unpaired electrons, labeled "3d" because they lie in the third atomic shell, or set of "orbits," of electrons. These unpaired electrons are of great interest to physicists who study solids.

The calculations, made by Richard E. Watson, were based on mathematics evolved about 30 years ago by Douglas R. Hartree, British mathematician and physicist: V. A. Fock, a Russian physicist; and John C. Slater, Institute Professor. Dr. Watson is a research associate in physics at M.I.T.

Dr. Watson's work could be compared very roughly to the task of calculating the attraction between each of 25 electrically charged magnets as they were continuously spun into the air by a juggler. As the whirling magnets changed position from moment to moment, the forces of attraction between any two – and among all of them – would constantly change. Taking a magnet away from the juggler or adding one to his collection would appreciably alter the environment of all.

One result of the M.I.T. work indicated that the removal or addition of an electron in an atom (ionization) had greater repercussions than had been anticipated. Although experimental physicists usually have ignored this effect, its size suggests that it must be included in any detailed analysis of atomic events.

The research was part of a broad investigation of third-shell electrons by the M.I.T. Solid State and Molecular Theory Group, through contract with the Office of Naval Research.

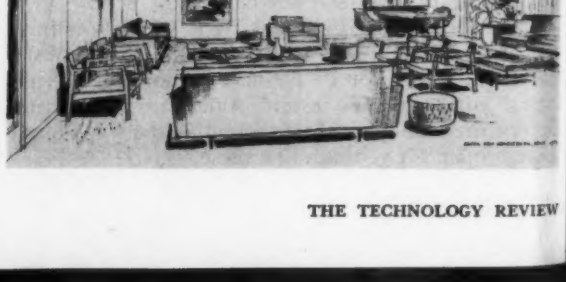
The Olive Barnard Memorial

BY mid-winter, the Olive Barnard Memorial room pictured below is scheduled to be completed for the School of Industrial Management. It is on the first floor of the Sloan Building, in which there previously was no place for undergraduates to meet friends, wait between classes or gather informally. Contributions from Alumni who were Miss Barnard's friends are being used to prepare it.

The committee for the Olive Barnard Memorial has William L. Stewart, Jr., '23, and Hugh S. Ferguson, '23, as co-chairmen, and includes: Dwight C. Arnold, '27, Peter B. Baker, '50, Jonathan Y. Ballard, '23, Monroe R. Brown, '42, Philip L. Coleman, '27, Wesley H. Loomis, III, '33, Joel Y. Lund, '23, Schrade F. Radtke, '40, Leburton D. Webster, '33, and John J. Wilson, '29.

Roach and Craven of Boston are the decorators.

(The Trend of Affairs is continued on page 44)



The Engineering Of Science

BY GORDON S. BROWN

M.I.T. is challenged now to produce the instigators of change in the future . . . and must find ways to accelerate greatly advances in engineering education

An engineer who is resourceful in science, who can remold the foundations of his profession as science advances, and especially one who can couple forward-looking judgment and keen intuition with his exploitation of science, is a precious member of society. He is much more than a custodian of current technology. His role is as vital to industry as that of the playwright in the theater.

Such an engineer classifies the recorded observations of scientists in ways which enable his profession to use them to foresee the outcome of new ventures, to predict the characteristics of new designs, and to evaluate the potentialities of new techniques. He does this by seeing relationships between seemingly unrelated events and pulling them together in quantitative ways. He thus creates new and useful configurations or systems. He purposefully forces the technological advances essential to the utilization of the findings of scientists. Such engineers have shaped our civilization and will shape our future.

How are they to be produced? After many months of discussion and deliberation, the M.I.T. Committee on Engineering Education headed by Professor E. R. Gilliland, '33, submitted a report to the Faculty this fall, which stated that the objectives of the Engineering School's program should be to give the student:

1) A good general education.

2) A thorough training in the basic and applied sciences.

3) The habit of thought that enables the engineer to handle complex problems with competence.

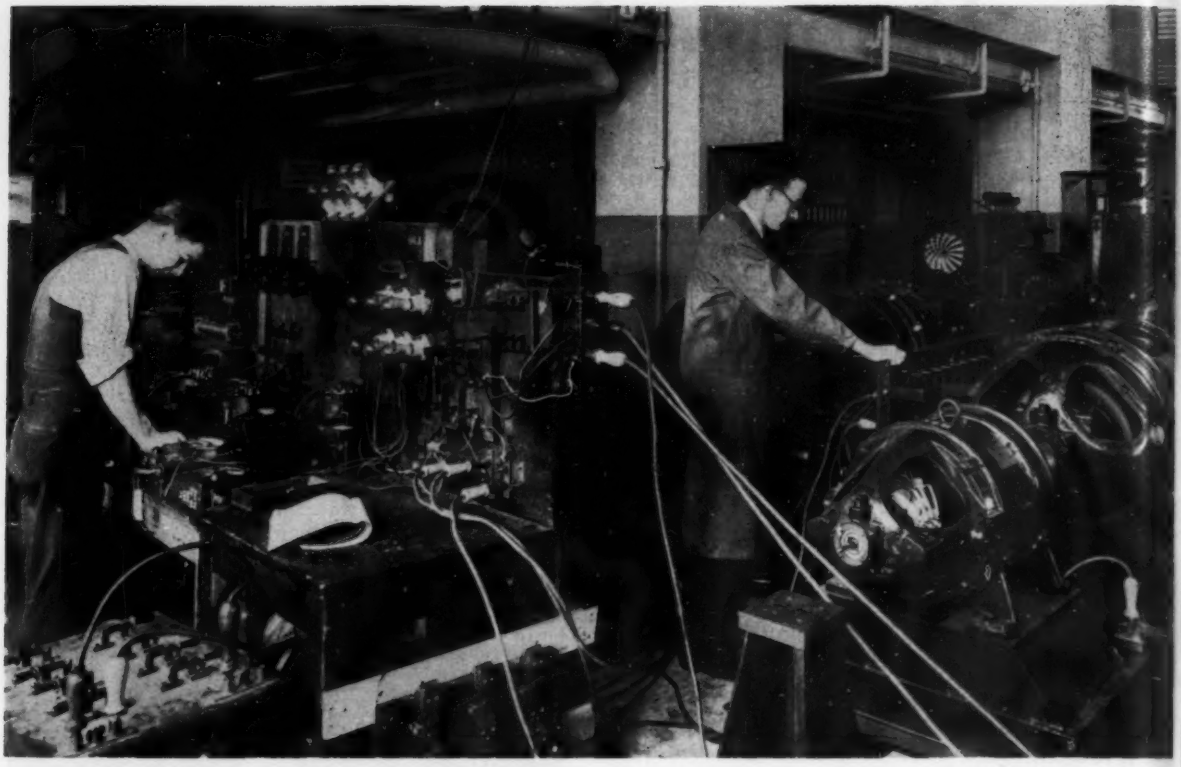
4) An appreciation of the methods of creating new knowledge.

"Stating the objectives," the committee added, "is much easier than formulating and implementing a program for their attainment." What makes this task especially difficult?

President Julius A. Stratton answered this question when he spoke, in his annual report this year, of three great forces which have buffeted the engineer-

Gordon S. Brown, '31, who became Dean of Engineering at M.I.T. last July, has been one of the busiest men on the Institute's staff this fall. He received both the American Institute of Electrical Engineer's Medal in Electrical Engineering Education and the Lamme Medal of the American Society for Engineering Education this year. He also found time to tour the Dew Line, and talked to the M.I.T. Alumni Council about it.

In this article he both explains the uses to which the recent grant from the Ford Foundation will be put and expresses some of his enthusiasm for enhancing the prestige of the engineering profession by strengthening the education of future engineers.



Few machines of this sort are left in the electrical engineering laboratory. This picture was made in the 1930's. There are fewer shutdowns with lighter machines used now, and instrumentation has become much more sophisticated.

ing schools increasingly, made some of the old curricula inadequate, and forced educators to consider drastic changes.

"First," he wrote, "there is the stupendous accumulation of new knowledge and principles flowing from advances in every field of science and engineering.

"Second, the nature of these advances is such that it becomes increasingly important that students of science and engineering have a thorough command of modern physics, chemistry, and mathematics.

"Third, the traditional boundaries that have long compartmentalized one professional field from another are rapidly dissolving away, with the result that the formulations of a sound professional education are constantly broadening."

The Challenge

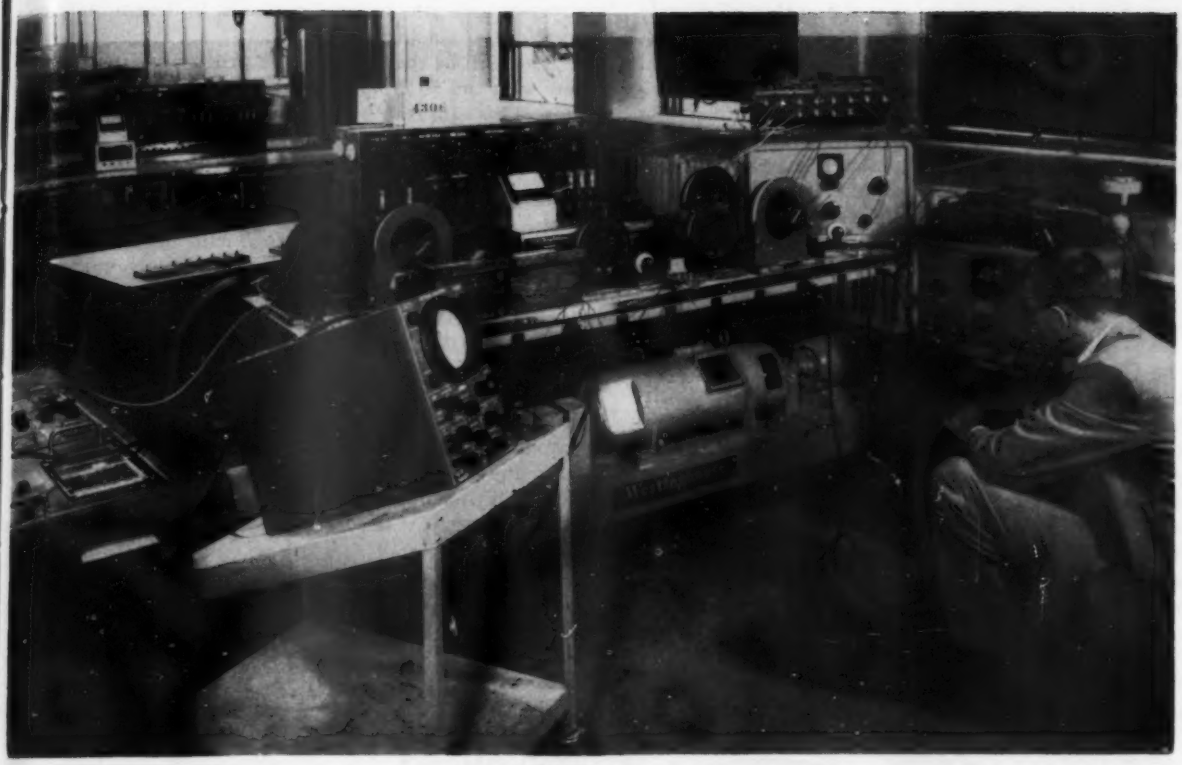
Scientific breakthroughs have come faster than engineers have been able to exploit fully the new data and concepts which have been made available. Scientists, in some instances, have become engineers, and the differences between science and engineering often seem trivial now to the layman. They were lost sight of in the Manhattan Project, and the press ignores them in reporting the efforts to explore space.

These differences, nevertheless, have significance. The engineer does not study heat, for example, merely because it is there. He anticipates and meets society's needs. He produces and delivers kilowatts when and where artisans can buy them. He devises new products which lighten men's burdens, prolong their lives, and give them fresh opportunities. He designs the new production techniques which industry must have to grow. He even produces the tools and instruments that the scientist must have to reach new frontiers. Now he must do all of these things more rapidly than in the earlier stages of the industrial revolution, and the next generation of engineers must be prepared to move even faster.

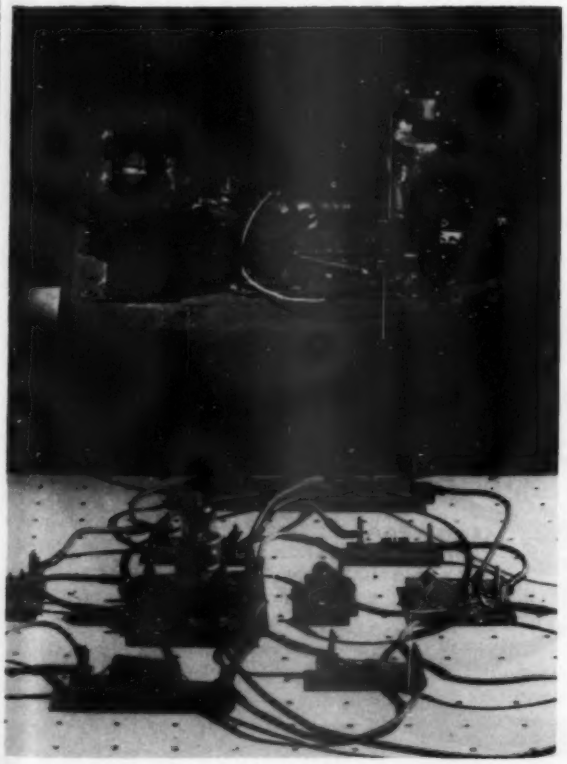
To practice any engineering specialty successfully in the 1970's a greater spectrum of knowledge will be required than was needed in the past. Already the electrical engineer, for example, is likely to be concerned both with the lattice structure of crystals and the role of computers in industrial operations; the civil engineer must appreciate both the potentialities of electronic data-processing and the complexity of radioactive waste disposal; and the mechanical engineer appears destined to be confronted with the need for machines which on the one hand operate at temperatures near absolute zero and on the other hand at the temperatures of man-made suns.

Some students have been quicker than teachers to see the need for more fundamental approaches to engineering problems, and there has been a drift away from the engineering classrooms towards the physics and mathematics departments. New courses in engineering are needed that students will recognize as manifestations of today's scientific frontiers, and that will in addition give them the insight and motivation essential to the successful practice of tomorrow's engineering.

This is the real challenge. It would be comparatively easy merely to present more science to future engi-



Here a Ward-Leonard speed control system is being used with one of the generalized machines in the M.I.T. electrical engineering laboratory, to study the effect of a feedback control system on the dynamics of a machine.



The Jiffy clip board in foreground is more flexible than the pre-wired breadboard formerly used in laboratory.

Lower power levels have reduced need for heavy leads, and aided study of dynamics and transient conditions.

neers. For the same reason that the author of a truly illuminating novel, or any other work of art, must be able to add something to the findings of the social scientists, the engineer must have more than knowledgeability about physics, chemistry, and mathematics — he must know how to shape their findings in new, useful, purposeful ways. The tough part of the program that we now envision at M.I.T. will be to help students acquire the purposefulness, the creativity and the sound judgment found in the brilliant engineering of science — and become men who will get new things done.

The Institute's Program

The Committee on Engineering Education at M.I.T. emphasized the need for a faculty of highest ability that understands and continually leads in new discoveries, and stressed a recommendation that "the undergraduate educational program be developed by means of bold experiments initiated by individual faculty members, by departments, and by inter-departmental groups." It called for prompt action "in the areas of engineering sciences, material sciences, core programs, superior students, tutorial methods, undergraduate research, and teaching aids."

This will be the target of the program we will carry out with the $9,275,000 grant from the Ford Foundation. This sum is to be used by the School of Engineering in six ways:

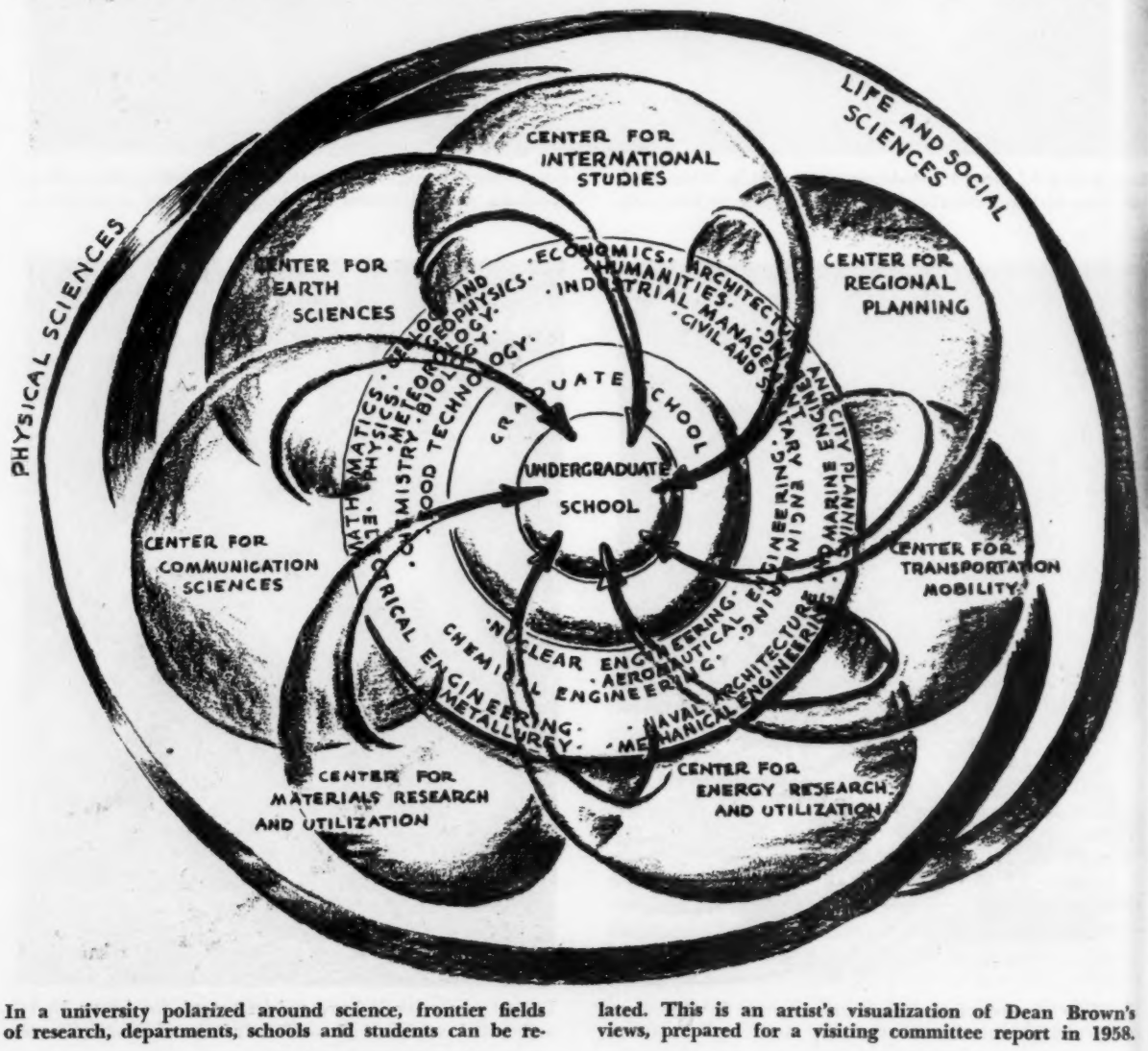
1) Seven additional professorships in important newly emerging fields of engineering will be endowed; this will take $3,500,000.

2) New syntheses of courses will be evolved, to couple the basic sciences with the newly emerging fields of engineering, and to introduce students to the "hardheaded" purposefulness of engineering; for this, $3,000,000 has been alloted.

3) New instructional laboratories will be developed to illustrate fundamental concepts and develop skill at experimental learning with new kinds of laboratory apparatus; $1,500,000 has been granted for such work.

4) Post-doctoral teaching internships and research fellowships will be offered to promising young men who expect to become professors; this will take $1,000,000.

(Continued on page 48)



In a university polarized around science, frontier fields of research, departments, schools and students can be related. This is an artist's visualization of Dean Brown's views, prepared for a visiting committee report in 1958.

M.I.T. Studies My Bones

Persons who took radium internally long ago now can help the Radioactivity Center staff study the effects of radiation

BY JEANNETTE JAMISON

Miss Jeannette Jamison, a teacher in Reading, Pa., is one of many people who took a medicine containing radium before much was known about radiation. Some of these people now are helping the Radioactivity Center at M.I.T., which for many years has been studying the long-term effects of radiation. This is Miss Jamison's story of her experiences.

Robley D. Evans, Professor of Physics, directs the work that Miss Jamison describes. It is conducted under contract for the Atomic Energy Commission. The Center's program has been intensified during recent years.

A nickel's worth of radium "taken internally by means of radioactive substance will kill a person in 10 to 15 years if it becomes fixed in the body."

This sentence flung itself at me early one November morning in 1936 as if it were the only news item in the paper and as if it were meant for me alone, telling me to forget everything on my agenda for that day. The pages of my fairly recent past — suddenly wide open — were staring at me! I wondered how I happened to be standing there alive. It was a one-sentence summary of a lecture given the day before to a group of physicians by one Robley D. Evans of M.I.T. and seemed to say more than everything the lecturer could possibly have said. I began looking at my years as I never had done before.

In 1926, I had a toxic goiter and a physician who was unwilling to have it removed by operation. He induced me to try the then very new radium-charged water called "Radithor." The word *radium* seemed to me to carry with it magic, the magic of perfect health suggestion, and Radithor was represented as an elixir of life that would make people lose whatever ills they might have. As far as I knew, I was in almost flawless health except for the goiter, but naturally I wanted to get rid of that. And so being easily convinced, I soon began something to which there can never be an end.

Radithor contained, I found out later, both radium and mesothorium, two powerful compounds well known for what they are to scientists, but not to the scientifically uneducated, of whom I was obviously one somewhere near the bottom of the list. This concoction was very costly; hence I thought it must be valuable. Like a goodly number of other incompetents, I laid in a considerable supply — at a dollar a bottle. Each patient was urged to take at least one a day. I thought I could better afford such expenditure from my modest salary than go on with a goiter growing up prominently on my neck for everybody to look at. Vanity seemed to be one of the several growing symptoms of distress.

Every day a dollar's worth of the promising stimulant gave me confidence together with an exhilarated feeling of well being. I felt exceptionally vigorous and happy while taking it. The goiter thrived like the rest of me, and did not diminish by the fraction of an inch. This went on and on for a long time — a dollar a day for over a year! Then for some reason I began to take smaller amounts. Just what argument I used to bring myself to this change, I do not now recall, for if several bottles a week could not do the trick, I do not comprehend now how I imagined fewer bottles could. At any rate, over the next two years, there was a gradual decreasing of the dosage from seven to three bottles a week, then to two and finally to one. At last however, I realized, with the doctor who was responsible for the original decision, that the whole performance was netting me nothing in regard to the lump on my throat. Several other doctors were of the opinion that an operation was all that would succeed and that there was no wisdom in waiting longer. So, three years after I had started taking Radithor, I stopped altogether

and in June of 1929, I went to Philadelphia's University Hospital for healing by surgery.

That was a long time before the Reading, Pa., *Times* gave me the jolt of my life on November 27, 1956.

* * *

On March 31, 1932, a well-known socialite playboy, who was also a steel manufacturer of prominence, one Eben Byers, died of radium poisoning in Pittsburgh, having imbibed, so the papers screeched from coast to coast, a radium-charged water called Radithor between 1926 and 1929!

The papers made much of this exciting item about Mr. Byers. He had been wealthy, and as I read, I perceived that he had not tapered off in his intake of the valuable stuff as I had. In fact, in my careful reading, I discovered that he had taken sometimes two, sometimes three bottles a day — in all, about 1,400 bottles. In my relative poverty I had taken possibly 400. There was, for a little while, at least, considerable satisfaction in the knowledge that I had taken about 1,000 bottles less. The broad headlines that marked Mr. Byers' passing were followed the next day by others, equally devastating to me, to the effect that 100 more persons were in danger of similar death. The laboratories in East Orange, N.J., evidently had been besieged by news hounds who had somehow searched the records of sales.

Knowing what I knew about myself, I read all headlines and articles in silence, realizing that there was not a thing I could do to change the situation within myself, to extract whatever residue of radium might still be in my bones from that exciting liquid I had enjoyed so much. I went as usual about my business of teaching English in the Reading, Pa., Senior High School saying nothing to anyone, but wondering often what the future held for me and how soon I should know. But the years passed smoothly, I was well, and my work gave me happiness, so I forgot all about radium and what it might do to me until suddenly Robley D. Evans gave a lecture to physicians and talked about what a "nickel's worth" would do.

How many nickels' worth of radium had gone into the fate that was in store for me? I did not try to figure it out. I did not need to; 1936 was the 10th year after my story had begun. I wrote to Dr. Evans and told him everything. Almost at once, I received a reply to the effect that it would be wise for me to visit those famous halls of learning and investigation, as speedily as possible, that it might be determined whether anything could be done for me or not. As my life was extremely precious to me, Cambridge did not seem too far away.

Dr. Evans told me by letter that he had been studying for several years with interested physicists, both in the West and the East, the question of counteracting the effects of radium poisoning and that "encouraging progress had been made." This was comforting, at least, and after the exchange of several letters regarding the time of my actual visit to M.I.T., I arrived on March 26, 1937. Dr. Evans received me with gracious friendliness, invited me to be seated there in his laboratories, and talked with me at length about my life up to date. I was unaware for a long time that there were electrical devices attached to the chair on which I was seated that were checking the amount of radium still occupying my bones and writing notes, via a mechanically controlled pencil, about the findings.

Upon leaving M.I.T. that day, I was taken to the Huntington Hospital, where a most friendly physician, Dr. Joseph C. Aub, of the Harvard Medical School, began immediately to investigate every bone in my body by means of x-ray machines to discover, if he could, any lingering bits of radium.

* * *

Results of all of the analyses made, all the information obtained, were sent to my regular Reading physician. There *was* evidence, they said, that there was stored in my bones enough radium to cause trouble in the future; just what or when or how they could not indicate. The only theory advanced as to why I had not already gone the way of Mr. Byers was that the radium taken during the growth of the toxic goiter might have been excreted because of the high calcium output associated with the goiter. A low calcium diet was prescribed for three months in the hope of pulling out radium from the bones. A dose of ammonium chloride was also prescribed to be taken every day for that length of time. I adhered faithfully to my instructions but I determined before I was halfway through that I should never be induced to repeat the experience regardless of results. Eventually it was learned that the procedure had been somewhat effective, in that, because of it, there was an infinitesimally smaller deposit of radium detectable.

All of that 22 years ago. Those wonderful people have kept in touch with me, writing to me every few years general letters of inquiry and of invitation to come again for observation. Six times I have gone, and six times I have been welcomed as an active partner in scientific investigations. What might have been an exhausting, gruelling trial has become, in this atmosphere of friendly co-operation, fun! In the early visits, we began joking about my "million dollar bones" and I became the "gamma ray guy." Often I have again sat, as I did that very first time, in the chair rigged up with all kinds of queer unintelligible wires, electric cords, things that looked like batteries but probably weren't, and long tube-like counters that reminded me of black bananas. Here and there were steel clamps that seemed to hold together long slender cane-like supports. Always the eminent and the sub-eminent personalities of the Institute have flocked around me — physicians and physicists, chemists and students of different fields — and I have felt peculiarly honored.

Mary Margaret Shanahan assists Dr. Clark in radioactivity work.

From left to right are Dr. Samuel D. Clark of the Medical Department and Professor Evans and Robert A. Dudley, '51, physicists.

Often a room or hall has been filled with mysterious apparatus, brought to that spot for the sole purpose of learning about *my* bones! The experiment that I have liked least every time is one in which I wear an aviator's oxygen mask over my face. They never provide a mirror for me, but I am sure I look like a black cat with a long tail wound coyly around my left shoulder. Brilliant-looking, pleasant, young men and women stand around muttering profound statements; at least, I can only suppose they are intelligent and profound, for they are far beyond my comprehension. These young students work now with one instrument and now with another behind "scalers" which are like huge batteries or in front of a huge glass (or, in the latest experiment, plastic) water container playfully called "Puffer II," which seems to be recording the radium or mesothorium in my breath. If you know how or why such a thing is possible, I salute you as a far wiser soul than I am. But ignorant as I am, I am thrilled each time by being in the presence of all of these intellectually elite.

Equipment such as this is used in the radioactivity laboratory.

The water tank test is always interesting. At least two, sometimes three, young scientists work on it. Sometimes the tank rests within a wooden framework and out of it emerges what seems to be another glass tank inverted and slightly smaller, which goes up slowly according to the rate of my breathing. Cast-iron weights on one side, attached to the tanks by means of ropes that run up over two different sized pulleys at the top, control its movement upward. I observed inside these glass holders a long slender glass tube that resembled a hollow cylindrical ruler with markings on it. By means of all this, the young scientists learn the secrets of my breath and its invaluable content of radium. Occasionally they leave the task and stand in a huddle discussing data.

At the side, the counters and scalers work on, ticking, or as in the latest visit, flashing little crimson lights, reminding everybody of telegraph offices on a night of a presidential election, but actually only taking an accurate record of radioactive elements in the room. The flashing counter is called a "scintillation spectrometer," which, I am told, has superseded the noisier Geiger counter and measures radium content not by clicking but by brilliant small flashes of red light, and is a much stronger detector. Endless seem the periods of watching this fascinating new invention! After its reactions to me have been noted, a "neutral" (person with normal bones) is put in my place and I am sent outside the room so that I may have no effect upon the recording. This goes on through the hours with me in various positions and at varying distances, and then the neutral takes his turn in the same poses and at the same distances.

* * *

In moments of freedom from these counters, I am escorted to the X-ray Department where joints and skull have their chance at inspection. Then an M.D. takes over. My life history since radium entered my living routine is reviewed, including my present habits, my eating, drinking, general living — all are given the most careful attention!

And throughout all of this procedure, every one of these distinguished and near-distinguished individuals becomes a personal friend, completely, honestly, considerately interested in my welfare. But as far as I know, not one of them has yet discovered why I still live in remarkably good health while Mr. Byers died a terrible death a quarter of a century ago.

Books

THE TEMPTER, by Norbert Wiener; Random House. *Reviewed by John Lear, Science Editor of The Saturday Review.*

PROFESSOR NORBERT WIENER, the father of cybernetics, has completed another experiment in communication. It involves the transmission of a message through the pages of a book entitled *The Tempter*. Contrary to his usual practice of eliminating all possible noise from his carrier channels, the professor in this experiment has introduced, with apparent deliberation, some confusion by allowing the book to be advertised as a novel.

Norbert Wiener*

The Tempter bears none of the conventional marks of the novelist's craft. It is not even cast in novel form, lacking either development of scene or dramatization of conflict. Unawareness being one trait that cannot reasonably be ascribed to Dr. Wiener, I must suspect him of something considerably more subtle: of making a test of the feedback mechanisms of American science under superficially annoying but fundamentally insignificant difficulties. The valid and vital question I read between his lines is this: Are scientists sufficiently sensitive in their perceptions to recognize a disaster call that is not preceded by the air-clearing cry of MAYDAY?

Presented as a long narrative letter from an older man to his godson, *The Tempter* sounds exactly like what it purports to be. The language is simple, straightforward, clear and compelling. The book gains, rather than suffers, from absence of the novelist's manipulation. No responsible man who was trying to pass on to a truly loved godson an honest account of the successes and failures of the godson's father would run the risk of "hopping up" his story. He would chronicle with restraint, understating every excitement. *The Tempter's* author writes his memoir in this fashion with such fidelity that, although Dr. Wiener insists his work is fictional, the reader keeps asking himself: Who are the real people behind the masks? What small eastern college, bucking for university status, prostituted its good name and its faculty's integrity in return for the gift of an expensive laboratory? Which professor sold his soul for $750,000? Whose solid old family name was used as a blind for the pyramiding of which of the present-day giants in industry? What famous theoretical scientist was robbed not only of money, but, more importantly, of recognition of the priority of his ideas, in order that a fabricated patent claim could stand up in the courts?

The significant thing about *The Tempter* is that a man of Norbert Wiener's stature, famed and far from penniless, still in the prime of his years with students at his feet, should feel the need to write it. Consider the large questions which this book raises:

At a time when the future of free men depends on the rigorous examining of nature, how can universities be returned to the approximate neighborhood of their own professed ideals of disinterested searching for truth?

How can the patent system be modernized to protect and encourage the innovators?

Can lawyers be brought to concern themselves with guarding honesty in expert scientific testimony?

What recourse will the young subordinates in research laboratories – academic as well as industrial – work out to protect their collective ideals from the individual maraudings of scientist-politicians?

An engineer-administrator is the villain of *The Tempter*, but the indictment that stands plain in this memoir from Professor Wiener's imagination does not stop with him; it reaches into the background of the times, where docile scientific societies back away from the real issues by voting medals in lieu of full recognition to original thinkers.

The Tempter deserves to be read by every man and woman of science. It ought to be read in conjunction with A. V. Kidd's new book on the relationships between government science and the universities. Together, these two volumes make it painfully clear that scientists can no longer expect to be exempted from responsibility for the social impact of their science.

MEN DIE, by H. L. Humes; Random House. *Reviewed by Frederick G. Fassett, Jr., Dean of Residence.*

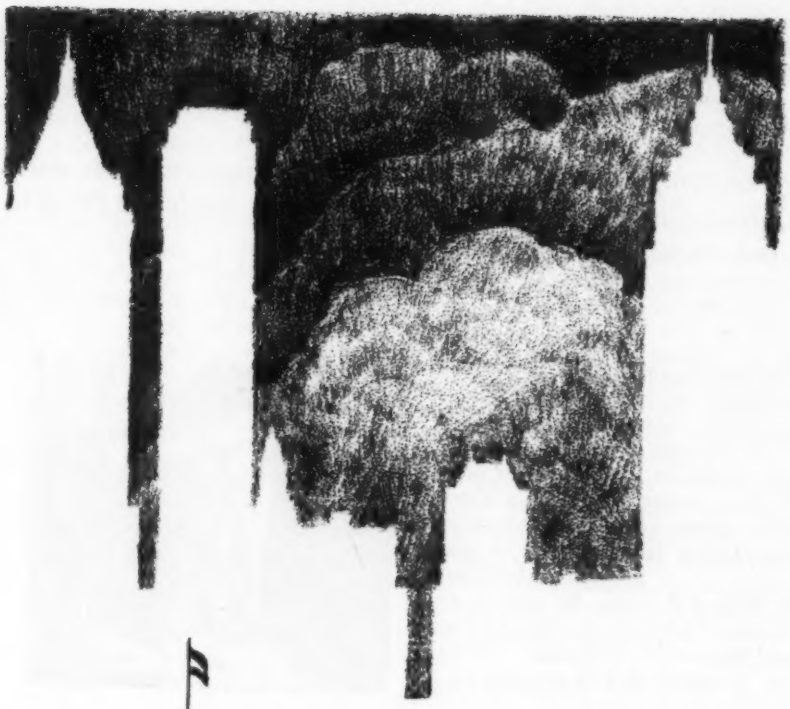
THE CORE of this rather swift-paced and impressionistic novel is an explosion that destroys an island ammunition base, killing all of its Navy garrison save six Negro seamen who are under arrest as mutineers and the Lieutenant (JG) who is their self-appointed warder. Such plot as the tale has consists of the gradual unraveling of the history of the dead Commander of the base, his dead second in command, his beauteous and high-strung widow, and the curious intermingling of their lives long before Hake, the Commander, drew his hated assignment. The Lieutenant (JG) who survives acts as intermediary in this unraveling, with the six mutineers – who are admirably realized – as the chorus and as perpetrators of a cosmic joke unrevealed till the end.

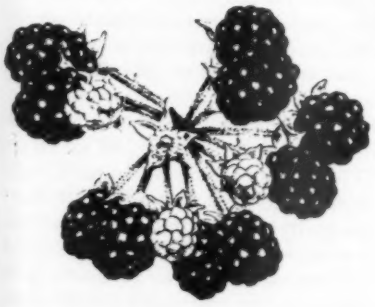
Stylistically, the book is at once interesting and exasperating. Mr. Humes, '49, can play Faulkner, Hemingway, Joyce almost at will, and does. For this rather unusual presentation of feminine eroticism, he employs not one but two streams of consciousness, the second apparently serving as commentary on the first. When he is himself, his prose is terse and vivid.

* From an exhibit of sculpture by Beatrice Paipert.

New York City's Natural History

THESE are illustrations from *A Natural History of New York City,* by John Kieran, published this fall by the Houghton Mifflin Company. They are the work of Henry B. Kane, '24, Director of the M.I.T. Alumni Fund, who also drew the sketches for the article that begins on the next page of this issue of The Review.





How Do We Learn Mathematics?

By showing, rather than telling, mathematical facts to students, some remarkable progress has been made in a continuing research project

Can the teaching of mathematics be improved, and more youngsters given the proper foundation for the study of science and engineering? Several efforts to answer this question are under way. One of them, which began operation in the Madison Junior High School, at Syracuse, N. Y., is a project established by Robert B. Davis, '46 (right), Associate Professor of Mathematics and Education at Syracuse University. It is described in this article.

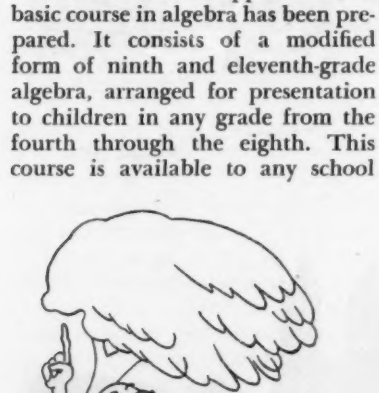
BY ROBERT B. DAVIS

THE Madison Project – a collaborative effort of mathematicians, teachers, psychologists, and psychiatrists – has pursued the dual objectives, since the fall of 1957, of improving the teaching of mathematics and investigating some basic hypotheses about who learns mathematics, how, and why.

For immediate application, a basic course in algebra has been prepared. It consists of a modified form of ninth and eleventh-grade algebra, arranged for presentation to children in any grade from the fourth through the eighth. This course is available to any school wishing to use it. As a result, a growing list of schools – in New York State, Connecticut, and Texas – are introducing algebra earlier than usual, and in a more creative form than previously. Fourth-graders are discovering for themselves that the product of the roots of the equation

$$x^2 + bx + c = 0$$

is equal to the constant term c, and they are enjoying the experience.



The Project, however, is concerned lest this specific course be overemphasized. It is a tangible result of two years of experimentation which does not stop at this point. As often happens, one tangible practical result can nearly obscure a continuing program of research. The experimentation is planned to continue into the future, without any foreseeable termination date. The Project has learned how to teach some eleventh-grade mathematics to seventh-graders – or even to fourth-graders – but this is a very small fraction of what may be learned if suitable means of investigation can be devised.

One Project activity has included teaching algebra and co-ordinate geometry to some potential delinquents in the seventh grade. These children came from severely deprived backgrounds. According to tests, they averaged an I.Q. of about 80.

The question then arises: What, exactly, does it mean to say that these children have an 80 I.Q.? The Project work thus far suggests several hypotheses. Much of their difficulty appears to be a severe limitation of verbal communication. When they are shown the *open sentence* (equation, in common parlance)

$$3 + \square = 5,$$

they will put a 2 in the box.

Without much recourse to language, they can recognize the equation as a "condition": that is, some numbers (namely 2) will produce equality, while all other numbers fail to do so. Moreover, they are able to use this understanding to solve the problem, even though nothing has been explained to them.

This nonverbalized concept of the student agrees precisely with the interpretation of modern logicians, who would say that the *open sentence*

$$3 + \square = 5$$

determines the *truth set* $\{2\}$.
(This same concept would, of course, be stated in traditional language by saying that the *equation* $3 + x = 5$ has the root $x = 2$.)

Now, when these students are asked to find the truth set for the open sentence

$$(\square \times \square) - (13 \times \square) + 22 = 0,$$

they can proceed to substitute numbers into the place-holding box by trial and error, and eventually conclude that the truth set is

$$\{2, 11\}.$$

For the sentence

$$(\square \times \square) - (14 \times \square) + 33 = 0,$$

they get

$$\{3, 11\},$$

and for the sentence (or, if you prefer, "equation")

$$(\square \times \square) - (16 \times \square) + 55 = 0,$$

they get

$$\{5, 11\},$$

Somewhere along here they make a discovery: if you *multiply* the two elements of the truth set, you get the last coefficient; if you *add* them, you get the middle coefficient.

They can now solve

$$(\square \times \square) - (5 \times \square) + 6 = 0$$

by reasoning:

$$3 \times 2 = 6,\ 3 + 2 = 5,$$

hence the roots of the equation are 3 and 2.

These "low-I.Q." students have discovered for themselves a mathematical fact usually taught in college, and they can use this fact in solving new problems!

The *mathematics* has not been too hard for them — in fact, it has been fun. But if we had *told* them the mathematical result, they would have looked at us uncomprehendingly. Words are not effective, it appears, in communicating with these children. Fortunately, we can *show* them mathematics with a minimum use of words.

Socratic Algebra

What, then, is the difficulty at the root of these children's "low I.Q."? Obviously, we do not know, as yet, but there are several tempting hypotheses:

1) The children have not learned to communicate effectively by using the literal meaning of words. (They *can* use words effectively to intimidate others on the playground.)

2) They require a great deal of adult attention, to compensate for deprivation at home. (When they have an answer, they want a teacher to come and look at it right away that instant!)

If mathematics gets immediate adult attention, they are willing to become interested in mathematics; if it does not, they can start a fight with their neighbor — this is certain to get immediate attention. They have very little frustration tolerance in this matter. Their need for attention is overwhelming; mathematics can interest them only if it is a road to adult attention instantaneously.

Obviously, one teacher cannot handle a class on this basis. The Project experiment has used as many as four adults in a room with 15 children. On this basis, it was possible to satisfy the craving for immediate attention.

3) These deprived children can learn only from an adult whom they like and respect. (They are strongly prone to suspicion and hostility.)

Under the right conditions, however, these "low-I.Q." seventh-graders can learn ninth and eleventh-grade algebra! They enjoyed this so much that their entire school work showed sizable improvement.

We believe you can use *questions* to teach things which you could not easily teach by making *statements*. To test this hypothesis we taught our Socratic algebra course to a class of gifted fourth-graders. The response was even more favorable than we had hoped. To our surprise the fourth-graders showed more talent for *abstract* mathematics than we have found among older children. This potential deserves considerable further study.

Define It Yourself

We have tested this approach further in a course in complex variables for graduate physics students. The physicists were asked to conjecture and prove the sequence of basic Cauchy theorems. They even had to develop their own definitions. This was done without reference to any text. The result had every appearance of being an unusually successful course.

(A similar "do-it-yourself" approach has been used for some years by Prof. R. L. Moore at the University of Texas; it is interesting to observe that Professor Moore's former students include a quite unusual number of outstanding present-day mathematicians.)

The algebra taught to fourth-graders has been *inductive* or *experimental:* that is, the students learn by generalizing from specific examples. We now plan to study the possibility of a *deductive* approach at the fourth-grade level: can children this age use *implication* as effectively as they can *generalization*?

Another hypothesis of the Project is that *secure learning* is a *nonverbal* result of *experience*. This can be explained by a nonmathematical simile: one can go from Harvard Square to Symphony Hall by having a written sheet of instructions, and following it carefully: "enter subway at Harvard Square, take train to Park Street . . ." and so on. If the instructions are correct, and if we follow them correctly, we will get to Symphony Hall. But there is a second way of navigating: we can spend time becoming well acquainted with the Boston-Cambridge area, and then use our familiarity to guide us.

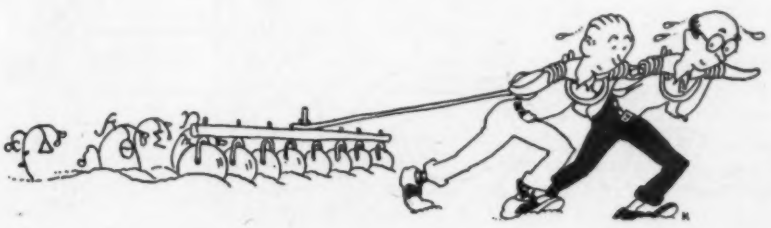
This second kind of learning, we believe, is far more secure and more flexible than the rote-verbal (or "cook-book") approach. This belief is another hypothesis we hope to test through the use of our Socratic teaching procedure.

Hard Ideas Early

The Project also hypothesizes that effective mathematical learning usually follows a pattern of "successive refinements": a student's notion of *derivative* (say) will embrace part of the idea reasonably well, but will not be fully accurate in detail. The Project is experimenting with this gradual successive refinement, in contrast with the more commonly used idea of trying to get a concept right from the very first.

Thus, for example, we can ask seventh graders to find a number which, when multiplied by itself, gives approximately 2. By trial-and-error, they may find 1.4. Now, if this is not a satisfactory approximation, they can continue the trial and error procedure, and find 1.41 as a somewhat better approximation.

This approximation procedure has a striking property: it is "arbitrarily" refinable — if you are not satisfied at some stage, you can go on to a still better approximation



that will meet stricter specifications. Any positive "tolerance" can be used.

By starting such ideas early, we can gradually refine them until we have (say, by grade 11 or 12) a well-developed understanding of the concept of *limit*.

This is another distinctive Project hypothesis: whereas some people believe that "hard" ideas should be deferred until later in a student's life, the Project is testing the opposite procedure. Precisely because these ideas are hard, we introduce them, in simple form, as early as possible, so that we have many years in which to refine them, and to investigate subtleties and implications. Thus, the Project begins with the ideas of slope, limit, equivalence, class, function, etc., at least as early as grades seven and eight.

Visualization With Vectors

Another hypothesis relates to *how we think about mathematics*. We are testing the hypothesis that the use of suitable semi-geometric visualizations is frequently superior to a purely verbal or symbolic way of thinking. Formally, one can say that

$2(x-3)+5(y-1)+3(z-7)=0$

is the equation of a plane. We can give this geometrical meaning, however, as the inner product of two vectors,

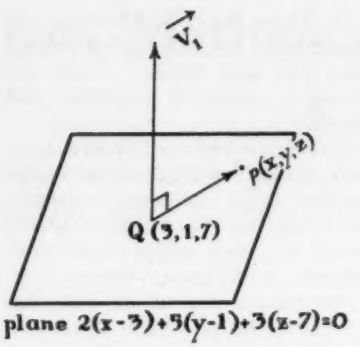
$$\vec{V}_1 = 2\vec{i} + 5\vec{j} + 3k,$$

and

$\vec{V}_2 = (x-3)\vec{i} + (y-1)\vec{j} + (z-7)\vec{k}$

which must, consequently, be perpendicular. This gives us a very valuable method for visualizing the meaning of the condition which the equation states.

Several distinctive features of the Project (which, incidentally, is supported by the Marcel Holzer Foundation of New York, and by the Alfred P. Sloan Foundation) have been suggested implicitly: for one thing, the Project is concerned with all mathematics education, from the elementary grades through

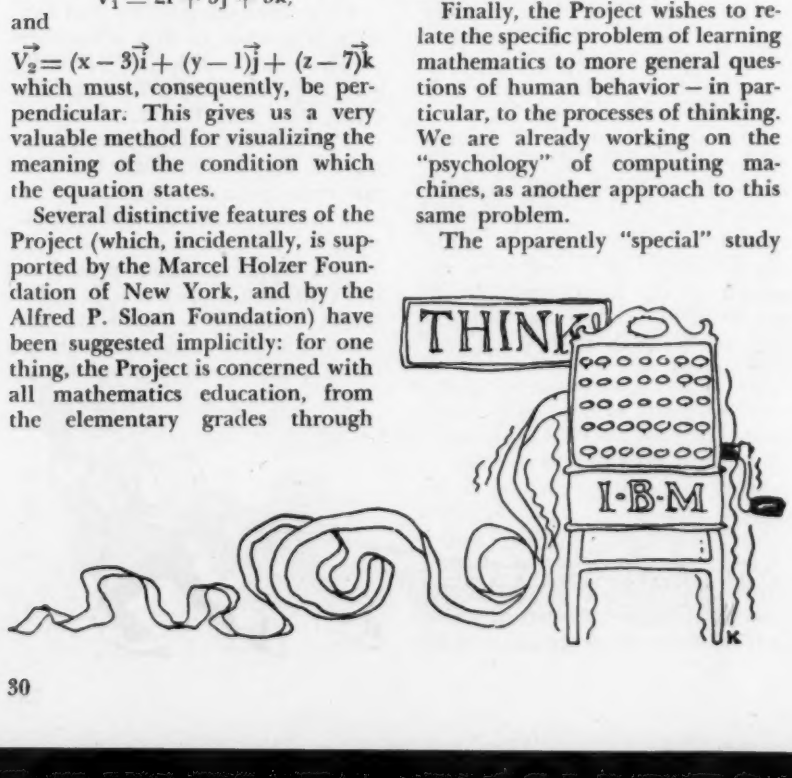


graduate school, since discoveries about learning in one area can often be used to illuminate others.

Moreover, the Project is interested in research under optimal conditions for learning — as, for example, in the work with delinquents, where we have used as many as four teachers in a single class of 15 students, in order to provide a generous measure of individual attention. The basic algebra course is a product of this research — it can be taught under typical school conditions, but the research itself is not limited to what can be taught by any teacher, or in any school. We are particularly eager to find the limits — what is the most that a student can learn, given optimal conditions for learning? We believe that this is, in fact, a very great deal — many people, we suspect, can learn a large amount of mathematics, given suitable conditions of study.

Finally, the Project wishes to relate the specific problem of learning mathematics to more general questions of human behavior — in particular, to the processes of thinking. We are already working on the "psychology" of computing machines, as another approach to this same problem.

The apparently "special" study of the apparently "hopeless" problem of mental illness gave rise to profound general insights of psychoanalytically oriented psychology. How people learn mathematics may seem a very limited field, and improving anyone's basic mathematical abilities may seem hopeless, but if we tackle this problem conscientiously, who knows what we may not learn?



A Teacher's Report On the New Algebra

THE Binghamton (N.Y.) *News* recently interviewed a teacher who had studied the method described in the preceding article, while at Syracuse University, and now is using it in his classroom. The newspaper reported, in part:

"The solution of 'unknowns' in even the simplest algebraic equations, long has been considered too tough for run-of-the-mill pupils below Grade 10 and even for some of the brighter below Grade 8. But Mr. Seely's 8B class is learning it, nonetheless, and the new way it's being presented to them this fall appears to be relatively painless.

"For one thing, the teacher is taking his time, permitting his pupils to learn, almost on their own, the fundamentals of solving equations.

"He's not telling them that it's algebra they're learning, in what is primarily a 'general math' class, nor is he giving them any algebraic rules to memorize. That seems to make a big difference in their responsiveness.

"Mr. Seely's class is one of several, in junior-high mathematics, where new concepts of teaching a traditionally dry and tough subject are being tried out in the Binghamton school system.

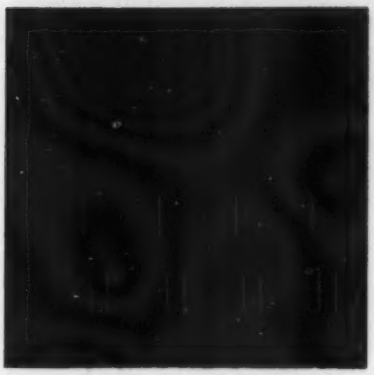
"The experimenting teachers learned new methods at various graduate-level college courses last summer, and returned to their classrooms to apply what they'd learned. . . .

"Mr. Seely, experimenting with the Madison Project method, said he will tell his pupils the rules only after they have learned to work the problems that apply to the rules.

"Thus, they will arrive at the rules, as did the mathematicians who originated the rules, through necessity, trial and error.

"Mr. Seely said he's getting 'excellent results' using the Madison Project method, and continued:

" 'It's getting rid of this old bugaboo of algebra being a monster. The introduction to the subject is very soft, using what the students already know. When they find it's easy, then I let them know they've been studying algebra all along.' "



by ELTING E. MORISON

The Pertinence of the Past

To write satisfying computer programs, we must first write them for ourselves

This paper, as it was delivered at a convocation of Sloan Fellows, began with a description of the war against the submarine in 1942-1943. In those years a series of decisions were taken by the armed services about the kinds of weapons to be used, the way in which the weapons would be used, the distribution of forces and command relationships. The purpose of this preliminary description was to demonstrate that in any situation involving men as well as materials and mechanical energies, there are always present, no matter how filled with quantitative data the situation may be, powerful human considerations that are still incommensurable. These incommensurables – a tangle of memories, prejudices, emotional needs, aspirations, common decencies and so forth – exert a tremendous and probably always a determining influence upon the real (or the total), as opposed to the exposed, nature of a situation. Any wise decision in such a situation must take into account not only the data from which logical conclusions about present operating efficiencies can be drawn, but that other data which leads to the non-logical understanding of what human beings are, need, and want to be. In the naval anecdote as told, the decision arrived at by a calculation of cruising speeds and fire powers was modified by a further calculation of the non-quantifiable needs of the naval society. That is why E. M. Forster, the British novelist, said that the only true history is the history of the human affections. All others, even economic history, he said in an unnecessary aside, are false.

With these things in mind my intention is, in this paper, to try to find out what may happen to the affections in the time of the computer. What I want to try to do is to raise a few very tentative propositions – an agenda of the kind of thing we will have to think about as we seek to live at peace with the machine. You all know some of the jobs the computer can do today – how it can prepare payrolls with deductions for the individual case, how it can assist in the control of inventories and the shaping of production schedules. As the illustrations for this article suggest, it has already entered, tentatively, the field of design. It can, even now, do something more.

For the last ten years I have had a Williamson circuit in my radio amplifier. In its utilization of the power available, in its capacity for internal correction, it faithfully represents the elegant solutions to technical problems that occurred to the man who made it – Williamson. It stands as an admirable expression of his own peculiar understanding and intuitive skill – as an expression, in other words, of himself. Today new circuits for conventional amplifiers like mine can be and are designed by the computer. The special aptitudes, the distinctive bundle of intelligence and affections that Williamson brought to his work – the bundle that was in fact Williamson – has been displaced.

Computers as you know have other competences. They can discover proofs for theorems of logic; they can solve trigonometric identities; they can do formal integration and differentiation. They can already or have given clear indication that they will in the foreseeable future be able to do the following things: remember, learn, discern patterns in loose data, make novel combinations of old information and, most striking of all, introduce surprise into an intellectual situation. There is still a question about the limits of the computer's imagination – its ability to create something like a Newtonian hypothesis or to construct something like Handel's Water Music. But Herbert Simon, a cautious student of these matters has said that, "Insofar as we understand what processes are involved in human creativity – and we are beginning to have a very good understanding of them – none of the processes involved in human creativity appears to lie beyond the reach of computers."

The capacities I have described – remembering, learning, discerning patterns, making surprising combinations of data – are most if not all of the capacities men bring to most if not all industrial problems. If I am correct in saying this, then it must seem that sooner or later the machines will be able to take part in the thinking that goes on at every level of an industrial enterprise; that they will be in a position to influence decisions that will effect the ultimate policies and purposes that govern our industrial life. No less certainly than the civilization of an armed force is based upon its weapon system, is the civilization of our society based upon the instrumentation of the industrial process. All our economic and social arrangements – how we feel about what we do, which

is all that culture is — is founded upon the way our industrial energy is organized. How large a part and what kind of part do we want the computer — with its overriding skill in rational analysis of the measurable data — to take in the decisions that determine the way this energy will be organized? This is worth thinking about.

* * *

There are lots of ways to think about it. If you are a Sloan Fellow now you can wonder how soon this machine will invade the ranks of middle management, and if and when it will reach the level of the Senior Executive if and when you actually reach those levels. You can also, if you are me, wonder when you will be out of a job. Because of the cheap reproducibility of computer programs it will, it is said, become cheaper and easier to transfer new knowledge and skill to machines than to men. As a faculty member I'm not sure it will be cheaper, but as a pedagogue long steeped in the educational process — with its immense inefficiencies and wastes caused by the uncertainties and resistances of human beings — I am quite prepared to believe that it will be easier for computers to teach computers.

But matters like this — the temporary technological unemployment of the individual — like you, like me, like Williamson — are inconsequential when laid against what I would think was the primary source of concern about the machine. The computer is no better than its program — the quality of its decision is determined by what is put into it and men will decide what is put into it. This is a source of hope and delight in one way. It means that like the steam engine, the steel mill, the dynamo, it is an opportunity to be exploited, an immensely powerful extension of man's ingenuity and power in the service of his will. But it is also a source, I should think, of concern. If we put the wrong things in it, if we select the wrong problems or state the right problems incorrectly we will get unsatisfactory solutions. Perhaps the easiest way to put it is that in using the computer man will get the answers he deserves to get.

Here it seems to me is the cause for real alarm because of a sad historical fact. On the record men have been luckier in giving answers than in asking the right questions — or at least they have been more skillful in making up half answers they can live with than in putting the full questions accurately framed.

This is not said in the hope that it will sound like an epigram. Let me give some brief examples out of our own short history. In the Constitution of the United States as it was ratified it is indicated that for certain purposes a colored man counts as 3/5 of a white man. In the 70's and 80's of the last century bimetalism was accepted as a solution to our monetary difficulties. Yesterday, today and apparently forever there is the legislation dealing with our farm problem.

These jerry-built solutions were arrived at in part because we did not care, for reasons of policy, expediency, ignorance or pure fright, to state the problems fully and accurately. Sometimes we did not assess the quantifiable data, as the weight of the silver bloc, correctly; sometimes we were not fully conscious of the load of memory, prejudice, hope, faith and so forth that had been dumped into the situation; and sometimes, indeed almost always, we did not make the effort to separate out the useful from the useless memory, the good from the evil prejudice, the legitimate faith from the illusion, in the problems presented.

In dealing with the computer, with its incisive capacity to reach clear decisions from the data presented, we will find ourselves in grave difficulties, I think, if we persist in such sloppy definitions of the problems we wish to solve. We will have, in the near future, to ask ourselves if we can assess even quantifiable data without distortion; we will have to consider painfully whether we are ready to lift out our raw affections for observation and analysis, whether we are honest enough and brave enough to make the necessary separations between the indispensable and the irrelevant feelings.

* * *

There is an alternative in all this that we ought at least to think about. We can begin from the proposition that man is because he thinks and only because he thinks. That is, we can disregard the existence of the affections and program only the quantifiable, measurable elements that can be dealt with by pure reason. Take, for instance, the antisubmarine problem as I have described it in 1943. Feed in the clean elements — radar capacities, fire powers, cruising ranges and so forth. Just the thing for a computer. Let us assume for the moment that a clean answer came back: use the land-based Army planes for search

and attack in the narrow waters of the Bay of Biscay. Let us then assume further that this sharing of control over operations and the introduction of the plane as a dominant weapon would undermine the naval society – altering not only its form but the structure of value and affection that held it together. This would mean that you had swapped cultural stability – determined in large part by the affections – for immediate operational success as prescribed by pure reason. When translated to the larger sphere of the industrial process and the cultural and social arrangements based upon it, the implications, I should think, are clear.

This is certainly one way to do it and it may be *the* way – or at least the way we will take. The history of man can be understood not only as the history of the affections but as the effort of man to use his distinctive instrument – the intelligence – to triumph over the affections, the effort to introduce logic and order into the control of affairs made messy by the affections. Then too, as is well known to all foreign observers, we are a pragmatic people living always for the operational success in the existing moment, unexcited by the past, unaware of any future beyond the next tomorrow which is only another day.

With such ideas in mind, and especially in an era of dynamic technological change, it may be argued that all the accumulated baggage of value and culture created by the affections is irrelevant or unnecessary. The thing to do is to reach logical conclusions in the immediate circumstance and bring such memories and affections as do exist into accommodating new alignments to fit the logical conclusions.

I want to take this proposition one step farther. Sigmund Freud had a theory that art is merely a neurotic compromise – an enormous effort by men to give imagined reality to desires they could not fulfill in action. It is possible that our affectionate attachments to particular schemes of value are equally symptoms of our incapacity to run an environment in a reasonable way. For instance in the 13th century a man petitioned Almighty God only, perhaps, because he thought he could control nature in no other way. Or a man in the 19th century made hard work, thrift, giving to the poor, and the sacredness of individual enterprise into a scheme of value because they were the only devices that enabled him to deal with an uncertain economy he could not run or understand by his reason alone.

If this view of things is accepted, and it has real pulling power for anybody attracted by economies of means, elegant solutions and nice analyses, then man can learn to live with the computer that feeds only on the quantifiable, measurable data and that yields up the correct operational decision for the moment. Detaching himself from familiar social, institutional and personal commitments he will be able to bring whatever affections he has into a continuous alignment with the ever changing decisions about what will work at this moment in the industrial process.

* * *

I think in the future we should look at this proposition with care, but I must say I don't like it much. It seems to rip man away from the qualities and contexts which in the past we have ordinarily pre-

sumed gave point and meaning to his life. It seems to turn him into an accommodating mechanism designed to force whatever fitful feelings he may have into grooves cut to a temporary pattern by the intellectual necessities of a situation. It sounds as though in the interests of survival we would be willing to survive as freemartins – dead to rapture and despair. Maybe I don't like this prospect simply because, as the anthropologists say, I am culture bound.

But I hope I am not misunderstood here. I believe, of course, that the intelligence is one of the determining things about man. I am with Whitehead when he said that today the rule is absolute, the society that does not value the trained intelligence will die. I also believe the computers are here to stay and it's no good trying to melt them down, as they tried to bust up the first power looms or to destroy the first Bessemer Converter built in this country. I further believe that the computers supply an opportunity to organize and enrich our society that is greater than the opportunity offered by any other agency perhaps since the discovery of fire – which also has the power to destroy. And finally, in this confession of faith, I believe that man is not only a creature distinguished by the intelligence but by the affections as well – which means I guess that he is a creature of rapture and despair. But which means also that the affections have an existence, an identity, a set of needs and claims, a shaping influence in the life of man that is their independent own. Man is, not only because he thinks but because he feels and it is the interaction between these two impressive energies that establish what people today love to call the human condition. This at least is one of the things I think I have learned from history. So I would add that in confronting the computer we must examine with care whether the rule is not equally absolute: the society that does not value the educated heart – or wherever the seat of the affections is – will also die.

Saying all this hardly simplifies the problem. The computer is no better than its program; the structure of the questions put to it is the determining thing. So what appears to lie before us in a rather distasteful phrase, is how – along with the quantifiable data – we can program the legitimate affections at work in a situation. If we can identify these affections and build them into the structure of the question we

want to ask, then we can put the computer to work in our own interest — we can make it a brilliant extension of our own natural capacities simply by asking it the right questions fully and accurately stated.

This means, I think, that we must soon get heavily into the business of finding out what our genuine affections and intentions are. We can not much longer resort to shrewd argument, or simple assertion, or name calling, or the power play to get our own way at the moment. We will have to find out first what our own way ought to be so we can frame the right questions. This means — in the end — finding out who we are — and, more painful yet — accepting it. Then we can program our emotional necessities and desires and even, I would suppose, our aspirations. In other words, we can write satisfying programs for the computers when, and only when, we have learned to write satisfying programs for ourselves.

* * *

How do we get the information we need and how do we make it explicit? This is not the place where you will get the final answer to the problem that has puzzled people since the beginning of recorded time. But some observations at least may be tentatively offered. Some of the information we need, some of the methods required to obtain further information are already available in the formal educational process. There is, to begin with, the old-fashioned source — the study of Humanities. Historically they have been an inefficient instrument, but they have always been and may remain as Sigmund Freud said of women, "the best thing of their kind that we have." But I think we might spend more time now trying to figure out ways to increase their educative power. They serve too often as mere diversions or as objects for critical analysis. They should be approached in such a way that a student may be stirred by them — in such a way that he recovers his power, now almost lost, to be really moved. The surest way to discover the existence and then to examine the meaning of the affections is first to feel them.

And then there are the newer means that give some promise — the social sciences like psychology, cultural anthropology and the rest. They are still young and tangled up with too many long words and far too much unorganized data. But they are today the most systematic methods we possess for analyzing the structure of the personality and for charting the course of the affections.

What the ultimate relation between the humanities and the social sciences will be I certainly don't know. I would hope that they would fortify each other — interact. I could make a case, for instance, that one could feel the full impact of Hamlet only after one had acquired an intellectual grasp of the structure of personality, the pattern of disturbed affections, so that one could recognize consciously what Shakespeare knew unconsciously.

One more thing about the uses of education here. It seems to me that we have reached a point of complication and sophistication in our culture where the things I have been talking about — the development of the instruments of industrial organization and our emotional and intellectual responses to them — cannot be learned once and for all in high school, college, graduate school, one Sloan year or ten weeks in a Senior Executive Development Program. To live safely in our society — let alone manage it — will require a continuous education until a man dies. It is steadily necessary to learn more about the changing environment, about the novel instruments we are putting into it and about ourselves as members of it. But education in the formal sense is not and never has been enough. We will need further incentive and means if we are to deal with our endeavor — which is to use the machine wisely by finding out who we are and abiding by what we find.

The preliminary incentive and strangely enough perhaps one powerful means lies in the computer itself. It is designed to give answers and to render decisions, but by its very presence and nature it puts the essential question, defines the central problem. Because it works only by simulation, it asks, it cannot avoid asking of its maker, what is the nature of man. This is the oldest question. Put forward in the past, as a matter of philosophic speculation, it has been possible to avoid the full consequences of insufficient answers offered by honorable men or of false answers supplied in cunning passages by fools and knaves.

But the machine which simulates will take our replies today to use in immediate and practical applications. If we withhold a full answer to the question it poses, we evade or equivocate at our own immediate peril. So the computer by its practical consequences can force man, for the first time, to raise up and examine his being (the being that must be, as they say, "programmed"), to face not only what he is but what he is doing, why he is doing it and what he wants to do.

If history means anything we will try to spare ourselves the pain of this investigation; we will, at times, get caught in traps sprung for us by fear or the pure intelligence. No doubt we are in for a dangerous time with an uncertain outcome. But there would seem to be no immovable obstacle to success. As I said earlier, much of our past difficulty has come because the problems have not always been well defined. It should now be added that men have demonstrated impressive abilities to solve problems once the definitions have been reached. They have revealed fortitude in awaiting outcomes, intellectual enterprise in the selection and combination of data drawn from schooling and experience, imagination in supplying new values for unknowns in the equations set, continuing concern for what is lovely as well as for what will work.

The computer has stated the problem crudely. What is left is to refine the definition and to solve the problem. To the dangerous work of solving it there is no reason to believe we will not bring the same qualities we have possessed in the past. Since the machine can only simulate, the work of creating the future is still in man's hands. If he fails, if he misuses the machine, then in simulation it will misuse him in exactly the same way. Then, in terms of what we ever thought we could be or hoped to be, we would have had it. If we succeed we will have acquired an incredible extension of the power of ourselves, our real selves.

BUSINESS IN MOTION

To our Colleagues in American Business . . .

Next time you open the door of your medicine chest remember: it's entirely possible that you are coming face to face with a Revere product that saved the manufacturer of that mirror frame on your medicine chest $10,000 a year.

Here's how this substantial saving came about. The Revere Technical Advisor calling on a leading maker of medicine cabinet mirror frames suggested that perhaps by changing the grain size of the brass he was using he might be able to save money on his polishing costs and at the same time improve the quality of his product. (The 90° bend to which the mirror frames are subjected also had to be taken into consideration.)

The suggestion interested the manufacturer and he asked the T.A. to submit samples.

Samples were made up, using a Revere Brass Strip with a smaller grain size than the manufacturer had been using. Tests showed that, as a result of the change the manufacturer was able to realize a saving of 17¢ per mirror frame on polishing costs alone, with no increased costs in other operations, including the 90° bend. Based on the saving per frame this manufacturer has saved $10,000 per year for the past 4 years!

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Individuals Noteworthy

(Continued from page 10)

In New Positions

ALUMNI now filling new positions, noted in the nation's press, include:

Warren A. Gentner, '13, President, New England Water Works Association . . . *David W. Skinner, '23,* Vice-president, Harvard Trust Company . . . *Charles S. Keevil, '23,* specialist in placement of scientific and engineering personnel, Helen Edwards and Staff Agency, Los Angeles;

Thomas E. Stanton, '27, Water Commissioner, City of Cleveland . . . *Richard M. Wilson, '30,* Manager, Film Manufacturing, Kodak Park Works, Rochester . . . *Raymond C. Binder, '30,* Staff, Washington State Institute of Technology . . . *Thomas B. Rhines, '32,* Assistant Engineering Manager, Hamilton Standard Division, United Aircraft Corporation;

Jacob J. Jaeger, '35, President, Pratt & Whitney Company . . . *Joseph M. Colby, '35,* Vice-president, Engineering, Rockwell Manufacturing Company . . . *William F. Whitmore, '38,* Consultant Scientist, Lockheed Missiles and Space Division . . . *Andrew C. Bayle, '40,* Vice-president, Engineering, Waltham Precision Instrument Company . . . *Clark Goodman, '40,* Vice-president for Techniques, Schlumberger, Ltd.;

Curtis D. Buford, '42, Vice-president, Operations and Maintenance, Association of American Railroads . . . *Lothrop M. Forbush, '42,* Engineer, Vehicle Development Group, General Motors Engineering Staff . . . *David B. Nichinson, '42,* Vice-president, Engineering, Kollsman Instrument Corporation . . . *Edward O. Vetter, '42,* Vice-president, Texas Instruments, Inc.;

Frank E. French, Jr., '43, Manager, New Product and Market Development, Du Pont Freon Division . . . *Robert B. Handelman, '43,* General Manager, Systems Division, Kearfott Company, Inc. . . . *Hamilton Herman, '43,* Vice-president, American Machine and Foundry Company . . . *John W. Hoopes, '44,* Director, Chemical Engineering Department, Atlas Powder Company Chemicals Division;

(Continued on page 38)

BELL SYSTEM TEAMWORK IS A VITAL FACTOR IN EFFICIENT, ECONOMICAL TELEPHONE SERVICE

Direct Distance Dialing is an example of the value of unified research, manufacture and operations

There are great advantages to the public and the nation in the way the Bell System is set up to provide telephone service. It is a very simple form of organization, with four essential parts.

Bell Telephone Laboratories does the research.

The Western Electric Company is the Bell System unit which does manufacturing, handles supply, and installs central office equipment.

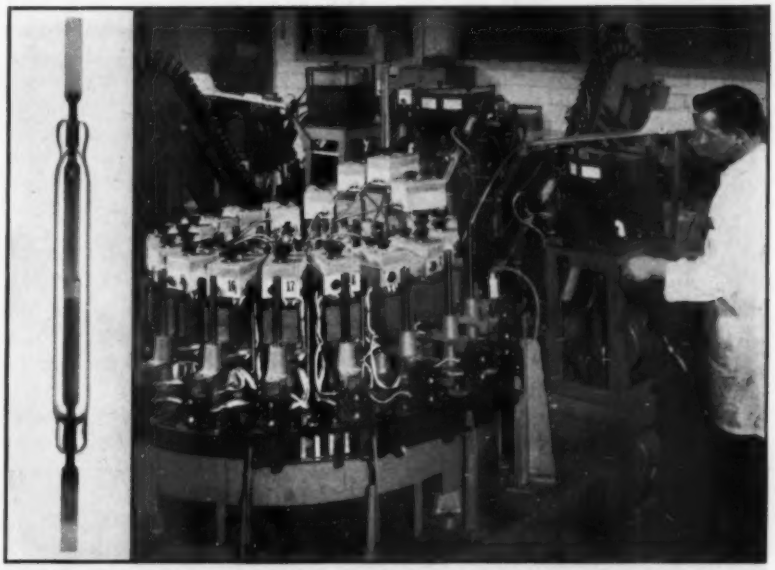
Twenty-one Bell Telephone operating companies provide service within their respective territories.

The American Telephone and Telegraph Company co-ordinates the whole enterprise and furnishes nationwide service over Long Distance lines.

Each is experienced and efficient in its own field. But the particular value of each is greatly extended because all four parts are in one organization and work together as a team.

Direct Distance Dialing—one of the greatest advances in the speed and convenience of telephone service—is an example of the value of this unified setup.

Already more than 8,000,000 telephone customers in more than 700 localities can dial direct to as many as 46,000,000 telephones throughout the country. Each month there are more. Millions of others can dial direct over shorter out-of-town distances. Calls as far as 3000 miles away go through in seconds.



EXAMPLE OF TEAMWORK. At left is new fast-moving switch (actual size) used in Direct Distance Dialing. Many of them go into action automatically every time you dial. Enclosed in gas-filled glass tubes to assure perfect contacts. Made to last 40 years. The result of Bell Telephone Laboratories and Western Electric working together to get the best and most economical design. At right is remarkable new machine, designed by Western Electric, which automatically assembles 360 switches an hour at a very small cost.

All of this didn't just happen. It called for years of intensive planning, the invention of wholly new machines and equipment, and the development of new operating and accounting techniques.

Research alone couldn't have done it. Neither manufacturing nor operations separately could have done it. And just money couldn't have done it, although it takes money and a lot of it for telephone improvement.

The simple truth is that it could never have been done so quickly and so economically without the unified setup of the Bell System.

For many a year it has given dynamic drive and direction to the business and provided the most and the best telephone service in the world.

BELL TELEPHONE SYSTEM

Individuals Noteworthy

(Continued from page 36)

Carroll J. Brown, '46, Executive Development Adviser, Standard-Vacuum Oil Company . . . *Clifford C. Woods, Jr., '46,* Assistant Vice-president, First National City Bank of New York . . . *Neil M. Blair, '47,* Vice-president, Intelex Systems, Inc., a subsidiary of International Telephone and Telegraph Corporation . . . *Kenneth L. Block, '47,* Partner, A. T. Kearney & Company . . . *Walter R. Derlacki, '47,* Assistant Research Director, Luria Bros. & Co., Inc.;

Van T. Boughton, Jr., '49, Manager, Cambridge plant, Dewey and Almy Chemical Division, W. R. Grace & Co. . . . *Donald J. Atwood, '48,* Associate Director, AC Sparkplug Research Laboratory . . . *Frederic A. Foss, '48,* Manager, Advanced System Research, Owego Facility of IBM Federal Systems Division . . . *Robert L. Sandman, '48,* President, New England Chapter, National Industrial Service Association . . . *Osmund T. Fundingsland, '50,* Director of Research, Raytheon Company . . . *Lawrence Gould, '50,* Manager, Tube Operations, Microwave Associates, Inc. . . . *William H. Ramsey, '51,* Secretary-treasurer, Boston Chapter, Professional Group on Aeronautical and Navigational Electronics, Institute of Radio Engineers . . . *William H. Feathers, '52,* President, National Carbon Company.

Recent Publications

INSTITUTE Alumni and staff members have been represented on the book marts this fall in:

Advances in Semiconductor Science, Proceedings of the Third International Conference on Semiconductors, in Rochester, in 1958, with contributions by J. C. Slater, Institute Professor at M.I.T., and Benjamin Lax, '49, of Lincoln Laboratory.

Factors in Special Fire Risk Analysis, by William D. Milne, '08. Priced at $10, by the Chilton Company, 5605 Chestnut Street, Philadelphia 39, Pa.

Fire Control Principles, by Walter Wrigley, '34, Professor of Aeronautical Engineering and John Hovorka, of the M.I.T. Instrumentation Laboratory. With 133 pages, it is priced at $10 by McGraw-Hill Book Company, Incorporated, 330 West 42nd Street, New York 36.

Molecular Science and Molecular Engineering, edited by Arthur R. von Hippel, Professor of Electrophysics. This completes a trilogy on modern materials research, contains 446 pages, and is priced at $18.50 by The Technology Press of M.I.T. and John Wiley & Sons, Incorporated, New York.

Property Measurements at High Temperatures: Factors Affecting and Methods of Measuring Material Properties at Temperatures Above 1400 degrees C, by W. D. Kingery, '48, Associate Professor of Ceramics, M.I.T. With 416 pages, it is priced at $16.50 by John Wiley & Sons, Incorporated 440 Fourth Avenue, New York 16.

Sampling Inspection Tables: Single and Double Sampling, by Harold F. Dodge, '16, and Harry G. Romig. This is a second edition of

(Concluded on page 40)

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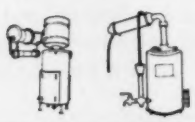

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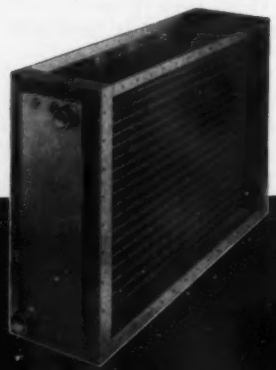

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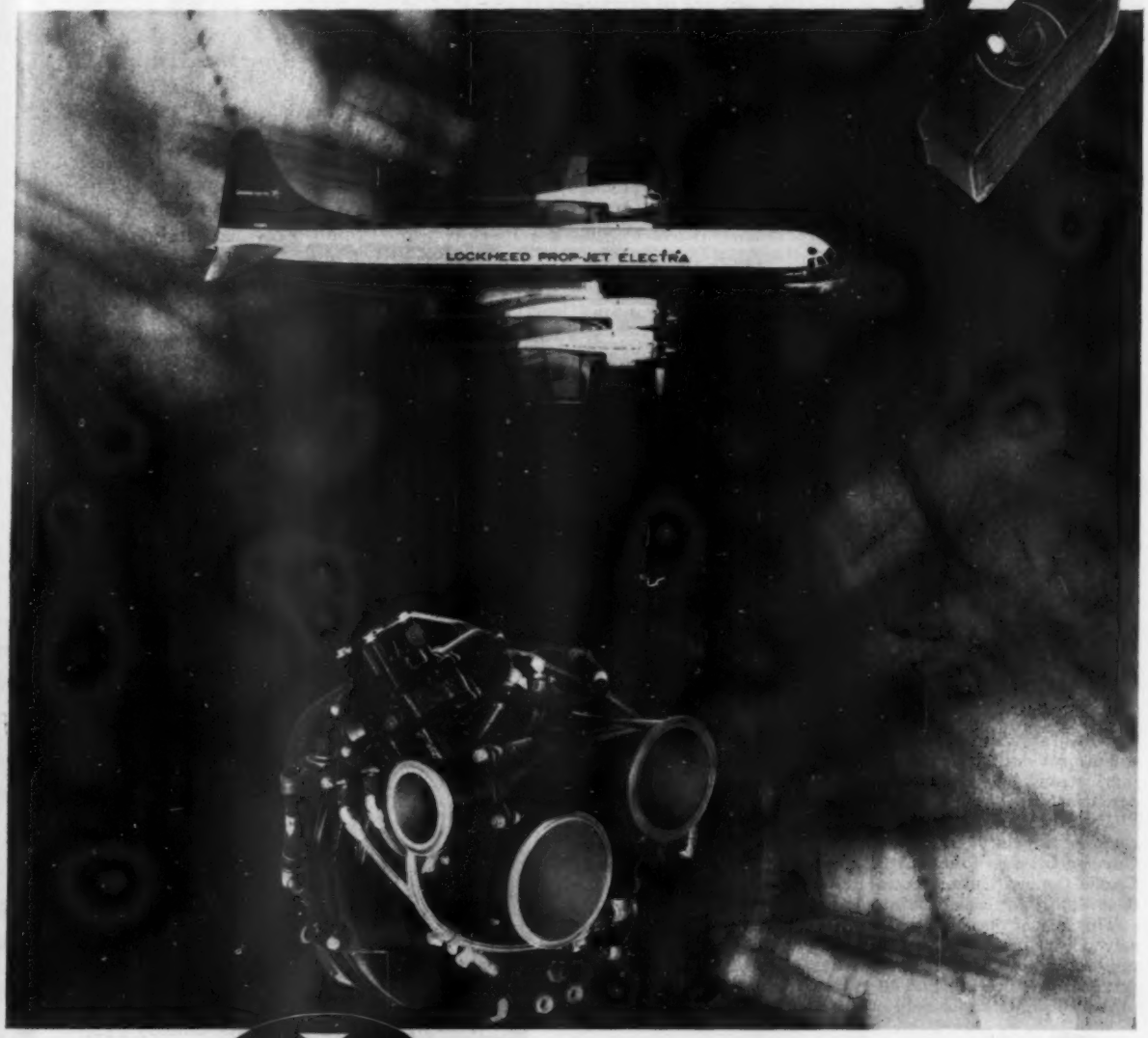

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Individuals Noteworthy

(Concluded from page 38)

a best-seller in its field; it has 224 pages, 8½-by-11 inches in size, and is priced at $4, by John Wiley & Sons, Incorporated, 440 Fourth Avenue, New York 16.

Structural Design for Dynamic Loads, by Charles H. Norris, '31, Robert J. Hansen '48, Myle J. Holley, Jr., '39, John M. Biggs, '41, Saul Namyet, '40, and John K. Minami, '31. Dr. Hansen and Dr. Holley are Professors of Structural Engineering, Dr. Biggs is an Associate Professor and Dr. Namyet is an Assistant Professor at M.I.T. The 453-page book is priced at $12.50, by McGraw-Hill Book Company, 330 West 42nd Street, New York 36.

The Dynamics and Thermodynamics of Compressible Fluid Flow, by Ascher H. Shapiro, '38, Professor of Mechanical Engineering at M.I.T. The first eight chapters of the author's two-volume work have been separately bound; with 119 illustrations and tables, and 294 pages, this has been priced at $8.50, by the Ronald Press Company, 15 East 26th Street, New York 10.

The Teaching of Human Relations (by the Case Demonstration Method) by F. Alexander Magoun, '18, with a foreword by Vannevar Bush, '16. This 169-page book is priced at $4.50 by Beacon Press, Beacon Hill, Boston.

Critical Problems in the History of Science, edited by Marshall Clagett, contains 16 major papers including one by Giorgio de Santillana, Professor of the History and Philosophy of Science at M.I.T. It is a companion volume to *The Science of Mechanics in the Middle Ages.* Priced at $5, it was published by the University of Wisconsin Press.

Visitors Nominated

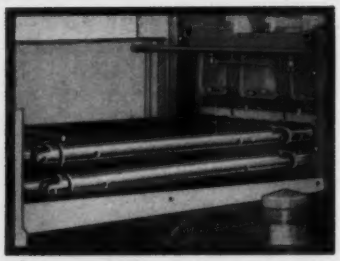
NOMINEES for Alumni Membership on Departmental Visiting Committees whose names have been submitted to the M.I.T. Corporation are:

William M. Mills, '34, Civil and Sanitary Engineering; *William J. McCune, Jr., '37,* and *Thomas F. Morrow, '35,* Mechanical Engineering; *Wilfred D. J. MacDonnell, '34,* Metallurgy; *Bissell Alderman, '35,* Architecture; *Harold S. Osborne, '08,* Regional and City Planning; *Frederick W. Adams, '21,* Chemistry; *Bennett Archambault, '32,* Electrical Engineering;

Robert L. Sinsheimer, '41, Biology; *Herman A. Affel, Jr., '41,* Physics; *Frederic A. L. Holloway, '39,* Chemical Engineering; *Douglas C. MacMillan, '34,* Naval Architecture and Marine Engineering; *Robert L. Moore, '21,* Economics and Social Science; *Laurence L. Waite, '29,* Aeronautics and Astronautics; *Ivan A. Getting, '33,* Mathematics;

Robert P. Joslin, '53, Food Technology; *Joseph L. Gillson, '21,* and *Joseph S. Bowman, '41,* Earth Sciences; *Abbott L. Johnson, 2d, '22,* Humanities; *Edgar B. Taft, '38,* Medical; *Nathaniel Rochester, '41,* Modern Languages; *William C. Foster, '18,* and *Elisha Gray, '28,* Sponsored Research; *Gilbert W. King, '33,* Library; *Richard L. Cheney, '27, Pierre S. du Pont, 3d, '33,* and *Thomas F. Creamer, '40,* Student Activity; *Semon E. Knudsen, '36,* and *Wayne J. Holman, Jr., '39,* School of Industrial Management.

How Curtis solved a close center-to-center problem



The close center-to-center spacing of these drive spindles on a Sutton-Maust Precision Backed-up Roller Leveler created a tough problem for its manufacturer. He needed a universal joint strong enough to stand up under heavy rolling mill conditions, yet small enough to operate at such close quarters.

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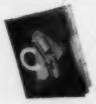

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Second Bank-State Street maintains accounts in foreign currencies in key financial centers of the free world — thus assuring prompt transmittal of funds either by mail or by cable. We can also make the conversion of dividends, royalties and other remittances from the foreign currencies into U. S. dollars (or vice versa) at favorable rates of exchange. This can be a great advantage to individuals as well as to companies.
Can I minimize my risks in the matter of credit and payments for merchandise?
If you're exporting, we can help with suggestions of credit arrangements which will expedite payment against your shipping documents. If you're importing, your problems can often be resolved by establishing the proper type of Letter of Credit in favor of your overseas supplier. Second Bank–State Street Letters of Credit are known and respected in all parts of the free world.
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Case Institute's Plans

SEVERAL M.I.T. Alumni who are now on the staffs of other schools will help implement the Ford Foundation's program to improve engineering education.

At Case Institute of Technology, for example, John A. Hrones, '34, Vice-president for Academic Affairs, will help launch a Systems Research Center and an Engineering Design Laboratory with funds granted by the foundation, and James B. Reswick, '43, Professor of Mechanical Engineering, will be director of the new design laboratory.

"Both the Center and the Laboratory will be based outside our existing departments," Dr. Hrones told the press in Cleveland, "yet will bring together men from many of our scientific and engineering departments for an interdisciplinary approach. . . .

"The Engineering Design Laboratory will provide a unique educational center in which students will be given the opportunity to solve the kind of problems met by the engineer in his professional practice. They will begin with a new idea and see it through the entire process of design and construction . . .

"The Systems Research Center will allow Case to make use of the talents of the entire faculty in setting up the first academically based center in the new field of systems engineering. This field is involved in projects as diverse as guided missiles and the organization of supermarkets."

Galloping Power Lines

AN ENERGY STATE called galloping is not confined to TV westerns. In the real world there is a more unsettling variety, to the elimination of which an M.I.T. project is now dedicated.

For many years power companies have been troubled by galloping transmission lines. During snow and sleet storms, the lines become coated with ice on the windward side and thus acquire an unsymmetrical shape which, in high winds, causes them to flap back and forth in periodic motions that may reach many feet in amplitude. The ensuing short circuits and damage to terminal connections have cost millions of dollars. These misfortunes are singularly rampant on the plains, where the flat open areas permit generation of constant and high air velocities over spans of several miles.

Efforts to solve the problem have been unsatisfactory to date, and 10 power companies have come to M.I.T. with a substantial grant for research into the matter. Albert S. Richardson, Jr., '47, executive officer of the Aerolastic Research Laboratory, will direct studies aimed at achieving fundamental understanding of the conditions.

Experiments will be carried out in the M.I.T. flutter wind tunnel, which produces velocities in the range from 10 to 100 miles per hour. Although there is some similarity to aircraft flutter problems, the work on power cables ventures into a relatively unexplored region of aerodynamic phenomena.

(Continued on page 44)

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The climb has been steady for Pres ever since he joined New England Life. Now he's really hitting his stride. He has qualified for our Hall of Fame as well as the Leaders Association he had read about not so long ago.

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Preston G. Adams, holding his youngest daughter Sharon, poses with Linda, Mrs. Adams, and Susan in front of their home in Salt Lake City.

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Charles E. Crawford, '31, Phoenix
Herbert L. Neitlich, '49, Boston

Ask one of these competent men to tell you about the advantages of insuring in the New England Life.

Trend of Affairs

(Continued from page 42)

The Meteoric Gun

AN UNUSUAL rifle range has been set up at M.I.T. to investigate what will happen when a meteorite hits a spaceship. The single gun used on this range can fire a projectile about three times faster than the fastest ordinary rifle bullets. It is a specially made, smoothbore, .243-caliber Winchester, and it sends a BB-size lead bullet through a pipe to hit a lead target 20 feet away.

Professor Raymond L. Bisplinghoff of the Department of Aeronautics and Astronautics directs the aeroelastics and structures laboratory where this shooting is done, and Walter Herrmann, a senior engineer, is in charge of the project. Working with him are two graduate students, Arnold E. Olshaker of Brooklyn and Arfon H. Jones of Llangennech, Wales, who are preparing theses concerning impact and wave propagation.

"For the past three months we have been operating our range to determine the effect of meteorite impacts," says Dr. Herrmann. "The findings have application more in the true space vehicle of the future than with the relatively small satellites now in orbit. A man-carrying space vehicle on a trip to Mars, for example, probably would be penetrated five or six times by meteorites large enough to do damage. It is necessary that some sort of protection be devised for at least the sensitive areas on a space vehicle — such as the manned compartment, guidance system, and power plant. Until better power plants are developed, space vehicles will have thin skins of metal, to save weight, so it is obvious that if meteorites are to be encountered, we must make sure the skin is not penetrated beyond the danger point."

The cartridges used in the meteoric gun have the lead projectile embedded in a plastic shoe, which keeps it from hitting the sides of the gun barrel, and its velocity is measured electrically. In most of the experiments, it has reached about 7,000 feet per second, and occasionally as high as 10,000 feet per second. Nevertheless, a shield about 1/30,000th of an inch thick can dissipate the penetrating power of one of these projectiles when it is placed about half an inch from the target.

Although the laboratory gun does not produce the velocity of a meteorite, calculations indicate that the speeds attained with it will produce the same results on a lead target that a true meteorite would on the thinner alloys currently being considered for use in space vehicles.

"So far in our experiments," says Dr. Herrmann, "we have reached the conclusion that for certain areas on a space vehicle, a double-skin will furnish a very promising means of protection. Now we are searching for the correct thickness of the protective plating, and also the correct distance to place it from the surface of the vehicle itself."

As more data are acquired, the researchers expect to make use of a large computer in this search.

(Concluded on page 46)

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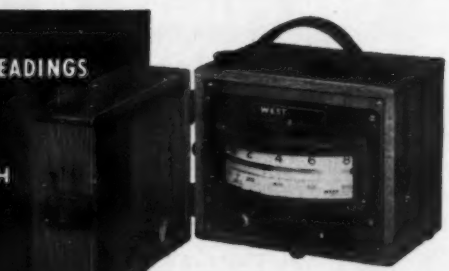

These rugged, handy precision-built instruments are widely used for taking spot readings where permanent installations are needless and for checking other instruments. Each mounts a Veri-Tell high resistance pyrometer in a gasketed aluminum housing, itself contained in practical Oak Case with lock and handle. Quick, positive service is assured by binding posts for attaching thermocouple. Automatic meter shunt protects meter when case is closed. Fully *guaranteed* and surprisingly *low priced.* Write for Catalog IE-1.

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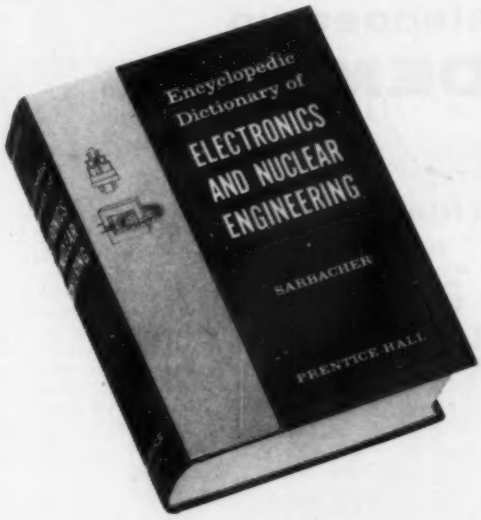

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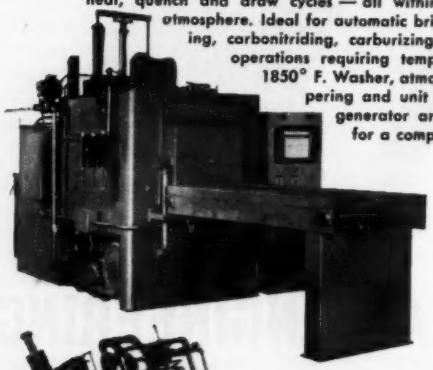

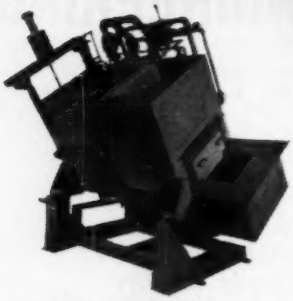

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Trend of Affairs

(Concluded from page 44)

The Alumni Council Meets

AT THIS academic year's first meeting of the M.I.T. Alumni Council, Gordon S. Brown, '31, Dean of the School of Engineering, and John B. Wilbur, '26, Head of the Department of Civil and Sanitary Engineering, entertained 173 members and guests with an account of their tour last summer of the DEW Line. In one week, they had covered 10,000 miles, visited 10 air bases, three DEW installations, and two BMEWS (Ballistic Missile Early Warning System) stations. Both were impressed by the ruggedness of the environment, and both spoke highly of the engineering achievements. Dr. Wilbur spoke first, emphasizing the distances and the civil engineering difficulties, and Dean Brown showed colored pictures he had taken and spoke of the sophistication of the electronic work.

Edward J. Hanley, '24, presided at this meeting, which was held on October 26 in the M.I.T. Faculty Club, and a report was given by Donald P. Severance, '38, Secretary, which showed:

¶ The Association's budget for 1958-1959. was $94,915, and total disbursements were $94,082. The unexpended balance of $833 is being returned to the Alumni Fund.

¶ The net profit, turned back to the Alumni Association, on Volume 61 of The Technology Review was $18,528, compared to $12,985 the previous year.

¶ Dr. Egon E. Kattwinkel, '23, has been elected to fill the two-year term on the Executive Committee of Henry B. Backenstoss, '34, who has moved temporarily to Beirut, Lebanon.

¶ Percy R. Ziegler, '00, has been elected to fill the vacancy on the Committee on Honorary Members left by the death of Bernard E. Proctor, '23.

¶ Chairman and Deputy Chairman, respectively, of the 1960 Alumni Day Committee will be Philip H. Peters, '37, and Albert O. Wilson, Jr., '38; and the following have been nominated as subcommittee chairmen: Mr. Wilson, Banquet and Evening Entertainment; Wolcott A. Hokanson, Registration; Robert C. Dean, '26, Symposium; and John L. Danforth, '40, Luncheon.

Edwin D. Ryer, '20, chairman of the Alumni Fund Board, reported that last year was the most successful in the Fund's history. "For the first time," he said, "we exceeded 15,000 contributors and passed the $500,000 mark. These were milestones in making annual giving a true expression of alumni feelings toward the Institute. To all who contributed and to all who also gave of their time goes the sincere appreciation of the Fund Board and M.I.T."

In accordance with a change in the Association by-laws, terms of the following six alumni members on the Alumni Fund Board have been established and will expire as noted below:

In 1960 — Whitworth Ferguson, '22, and D. Reid Weedon, Jr., '41; in 1961 — Avery H. Stanton, '25, and John J. Wilson, '29; in 1962 — Edwin D. Ryer, '20, and Dwight C. Arnold, '27.

A resolution occasioned by the death of Henry F. McKenna, '25, was read by Frederick W. Greer, '25.

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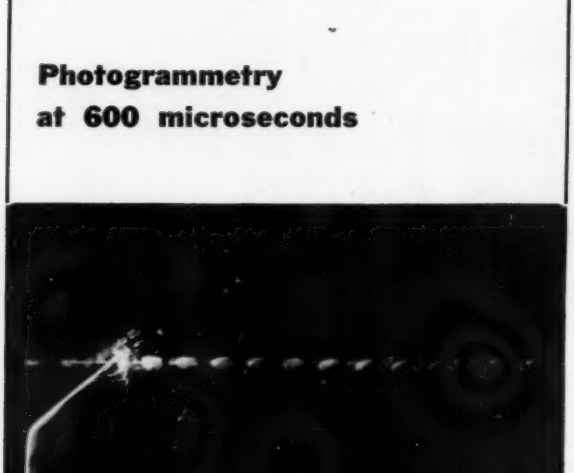

FIFTEEN FLASHES at one microsecond duration and 40 microsecond intervals show .22 calibre bullet traveling 1,200 feet per second as it splits a piece of soft iron wire. The photograph was taken by Dr. Harold E. Edgerton of MIT. The Multi-Microflash Unit developed by the scientific instrument firm, Edgerton, Germeshausen & Grier, Inc., is an invaluable tool in stroboscopic studies of ultra-high-speed phenomena.

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The Engineering of Science

(*Continued from page 22*)

5) Fellowships and loans will be made available to graduate students, from industry as well as colleges, who wish to work toward the doctor's degree in engineering with the expectation of becoming professors; $150,000 is available for these.

6) The education of promising young members of the Faculty will be extended by bringing distinguished engineers to M.I.T. as visiting professors, exchanging professors with other colleges, and conducting conferences on educational problems; for faculty development in such ways, $125,000 has been provided.

In short, about half of the Ford Foundation's grant is intended to be used to strengthen teaching. The rest will support efforts to evolve new course sequences and laboratory procedures.

The Core Curricula

Many of the men now teaching engineering obtained their basic education before the war. Discoveries and developments since then in solid-state and molecular physics, the quantum theory of matter, spectroscopy, magnetohydrodynamics, and in computers, operational analysis, jet propulsion, and so on, have made it difficult to keep up with changes in one's field while carrying a substantial teaching load. The good teacher, moreover, should also be sensitive to developments in adjacent fields. Additions to the faculties can both help relieve senior teachers and improve the work of junior teachers in many ways.

Such interdisciplinary centers as the Insulation Research Laboratory, the Research Laboratory of Electronics, the Laboratory for Nuclear Science and the Communication Sciences Center have helped bridge the gaps between traditional disciplines at M.I.T.; more such centers are needed, and will be established. These centers, which are in essence federations of scholars, also can be helpful in creating the fresh syntheses in interdisciplinary core curricula that are contemplated now for undergradutes in the School of Engineering.

The specific areas that these core curricula will embrace are currently live topics of discussion as the Faculty looks imaginatively to the horizons of the next decade or two. They may follow such themes as:

Materials — Engineers are increasingly concerned now with the ways in which atoms and molecules can be manipulated and engineered to produce new substances and devices. The transistor is an outstanding example of a momentous engineering application of the exploitation of fresh scientific understanding. Throughout all engineering, new and improved materials are urgently needed, yet few schools are giving their students the competence they will need to become leaders in what eventually may become a wholly new field called molecular engineering.

Energy Processing — For a long time man has been mining coal to obtain power. The coal is shipped to a power plant, where it is converted into heat, which is converted into steam, which turns turbines, which turn dynamos, which generate electricity, which is sent through wires to consumers. Must the process

be so ponderous and inefficient? Science has uncovered many new possibilities for processing energy to produce electricity and to produce work in a multitude of new ways. Engineers are needed who can devise simple, economical, feasible processes.

Information processing, propulsion, and *environment engineering* are other possible themes for core curricula. There has been much interplay between departments within the Institute's schools, and between the schools, too, in the past which will prove helpful as we seek fresh snytheses in such curricula, not only with respect to science, but also with respect to the resources of the whole of M.I.T.

Achievement of these aims will involve a major reorganization of the educational work and the organizational structure in our School of Engineering. The undergraduate programs will gradually acquire more of a common status for all lines of engineering. As this lessens the specific professional aims of the present departments in the undergraduate years, the departments' roles in the graduate study and research domains must be correspondingly strengthened.

Time Is a Factor

At an electrical engineering curriculum workshop here two years ago, Chairman James R. Killian, Jr., '26, of the M.I.T. Corporation, said: "Many of us feel intuitively that we may be on the verge of an advance in professional engineering education not unlike the advance in medical education which followed the Flexner report and the revivification of legal education that followed the innovations of Langdell."

It already is launched. New textbooks, new laboratory devices such as the generalized machine, and other innovations in the Department of Electrical Engineering have so changed its whole educational program that a man who was graduated a decade or more ago now would find it quite strange. Other departments, too, have striven — each in its own way — to adapt themselves to new conditions, and many excellent results have been obtained. But much more must be done, and done quickly. We must accomplish in the next five years or so as much as has been accomplished by slow evolution in the last 50 years.

Our school must do more than keep up with the swift pace of technology. We must produce engineers so versatile, and so well equipped to exploit science, that they themselves can be the instigators of greater changes than history has recorded heretofore. We must educate engineers who, by their ability, can shape modern scientific knowledge into useful new forms — the revolutionists in tomorrow's revolution in technology.

Recommended Reading Elsewhere

TO the November issue of *Scientific American,* Bruno Rossi, Professor of Physics, contributed an article on "High-Energy Cosmic Rays." . . . For the October issue of *Physics Today,* M. Stanley Livingston, Professor of Physics, wrote the first part of a "History of the Cyclotron." . . . In the October 10 issue of *The Harvard Alumni Bulletin,* Malcolm D. Rivkin, '56, Planning Officer at M.I.T., wrote about the Youth Festival in Vienna last summer which he attended with others from the Cambridge area.

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Talk of Our Times

Can We Afford Beauty?

Edward D. Stone, '27, in an address to the American Institute of Architects in New Orleans this year, said in part:

AS WE VIEW our cities, towns, villages and our countryside, I am afraid we must acknowledge that we are a people who have not yet learned to appreciate beauty.

Henry Ford did not realize that his invention would render a whole continent's plan obsolete. Nor did Claude Neon think that his simple lighting device would doom the beauty of the world's greatest avenue, the Champs Elysées in his native Paris, or Canal Street, the great thoroughfare of this city.

The automobile, the neon sign, the atomic pile, are all lethal unless controlled. We all know that grass should grow on Main Street and that it should be a pedestrian oasis with parking around the perimeter. This principle applies with equal force to large cities. We idealize the Piazza San Marco—a market place and civic center for pedestrians and free of motor traffic. Why can't we guide the city father in the creation of many such poetic situations in our metropolitan areas? . . .

Modern architecture is in its adolescence and currently is happily diverse and with many enthusiasms.

To some, redwood is God's greatest gift to man.

To others, plate glass holds the place today that Pentelic marble held in the time of the Greeks.

The plastic possibilities of concrete enable others to build great blimp-like structures.

Steel in tension holds another architect's world together. All of these points of view are healthy and enrich our basic vocabulary. . . .

We mustn't be creatures of fashion and duplicate one another's work, washing out our creative birthright. Architecture idealistically is permanent and should find its inspiration in the accumulated experience of history, if it is to be an ageless art. . . .

Since the horseless carriage is largely responsible for all of our troubles and we are a country that eulogizes free enterprise, why hasn't it occurred to our great oil and automobile industries to try to resolve some of the problems they have created. Why can't they be shamed into planning studies of our countryside, our villages, our towns, and our cities? To these great corporations the financing of such studies would be peanuts. . . .

Our government must be made aware of its responsibility. To accomplish this we need a cabinet official, corresponding to the Secretary of Agriculture, with outposts in every state and architects and planners to guide communities, just as the state and county agents have educated the farmer. . . .

If programs such as these were inaugurated, our profession would begin to fulfill its destiny.

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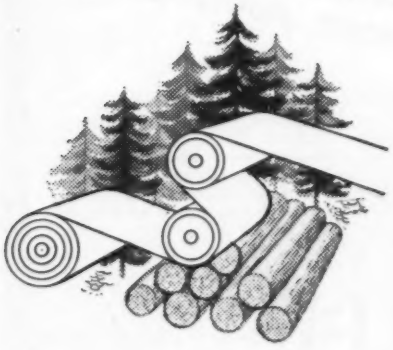

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Institute Yesteryears

25 Years Ago . . .

UNDER the heading "50,000 Subtractions a Minute," The Review for December, 1934, reported that the Institute's three-year old Spectroscopy Laboratory, directed by Professor George R. Harrison, was "housing an elaborate program of investigations on the structure of matter as determined from the light emitted by atoms and molecules . . . made possible largely because [of its] concave grating spectrograph of 35-foot radius of curvature, [which] has been said by visiting spectroscopists to contain the most powerful diffraction grating ever made.

"A short time after the first successful spectrum photographs were made with this instrument the laboratory staff found that with it one man, by working two or three hours, could take a sufficient number of spectrograms 40-feet long, each containing thousands of lines, to keep several men busy for six months or more measuring, computing, and tabulating the results. It soon became evident that to make the best use of the unusual equipment available unusual methods of carrying out these processes must be devised.

"To meet this need, two entirely new instruments have been designed and constructed: one, still under development yet almost constantly in use, is a machine for measuring the wave lengths of spectrum lines directly from the spectrum photographs and for making all necessary computations automatically; the other, which is complete and has been in operation for more than a year, is known as an 'interval sorter,' and is designed to determine the energy levels of atoms or molecules from the spectrum lines they emit."

◀ On December 6, 1934, the Institute mourned the passing of Allan Winter Rowe, '01, Secretary of his

(Concluded on page 54)

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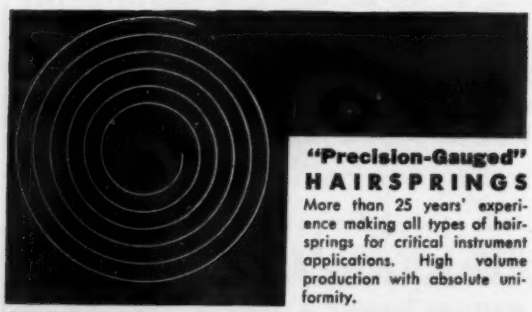

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Institute Yesteryears

(Concluded from page 52)

class for 13 years, member of the Advisory Council on Athletics for 23 years, member of the Alumni Council for 24 years, in 1932-1933 the 39th President of the Alumni Association, and since 1933 an Alumni Term Member of the Institute Corporation.

50 Years Ago . . .

IN his first Annual Report as the sixth President of the Institute, Richard C. Maclaurin, made reference to the large amount of important research being carried on by members of the Faculty in addition to their teaching duties. This, he believed, was "the very breath of life in a scientific school. The Institute has been particularly fortunate in having on its Faculty men who recognize this thoroughly, and it is not a little remarkable that many of the most important contributions to pure science that have been made within recent years in America have been made by graduates of the Institute of Technology, which on its scientific side is popularly, although of course quite erroneously, supposed to be almost exclusively a school of applied science."

In concluding his report, Dr. Maclaurin said he realized "that most of the Institute's difficulties are due to its success and not to its failures, and I believe that a splendid future is assured to it, if at this critical stage of its history it does not falter through lack of courage. It seems to me that when the opportunity arises it should sell that part of its property which is unrestricted [and] with the proceeds secure a new site."

75 Years Ago . . .

FRANCIS AMASA WALKER,* the third President of the Institute, in December, 1884, commenced his Annual Report on an optimistic note. "The last school year," he wrote, "has witnessed the full maintenance, and even an acceleration, of the remarkable rate of increase in the number of students attending the Institute of Technology, which has characterized the era of comparative prosperity which began in 1880. . . . We find the number of students in the School of Industrial Science to be 579, against 433 last year; making an increase of 136, or 31 per cent. . . .

"Large additional endowments are needed . . . as a reserve against hard times, against the occurrence of financial disaster, and even against the possibilities of temporary internal mismanagement. It is a perilous position for an educational institution that it should depend so largely upon tuition fees as to draw one-half of its revenue from this source. Yet five-sixths of the income of the Institute of Technology will be thus derived during the current year."

100 Years Ago . . .

ON December 7, 1859, William Barton Rogers was being congratulated upon the occasion of his 55th birthday.

*President Walker had taken office October 1, 1881, with a salary of $5,000 per annum.

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and the prophet replied:
*"It is well to give when asked, but it is better to give unasked, through understanding."**

Gifts by Will

TO THE

Massachusetts Institute of Technology

The tale is told of Almustafa, the prophet, who, having awaited for many years the ship that would return him to the place from whence he came, was making the final descent to the shore when the folk of Orphalese crowded about him. They besought him before departing to "disclose us to ourselves, and tell us all that has been shown you of that which is between birth and death."

With words of wisdom, an answer appropriate was given to the woman holding a baby, to the ploughman, to the merchant. Begged one, "Speak to us of GIVING," and the prophet replied:

> "It is well to give when asked, but it is better to give unasked, through understanding;
> And to the open-handed the search for one who shall receive is joy greater than giving. All you have shall some day be given;
> Therefore give now, that the season of giving may be yours and not your inheritors'."

Through the years the prophet's words have held true, for even today he who "through understanding" includes the MASSACHUSETTS INSTITUTE OF TECHNOLOGY as a beneficiary in his will can experience thereby a two-fold satisfaction. The successful culmination of his search for a worthy recipient and the anticipated results his generosity will assist in accomplishing. These satisfactions give an added value to the span of man's days and project his usefulness to his fellowmen far into the future.

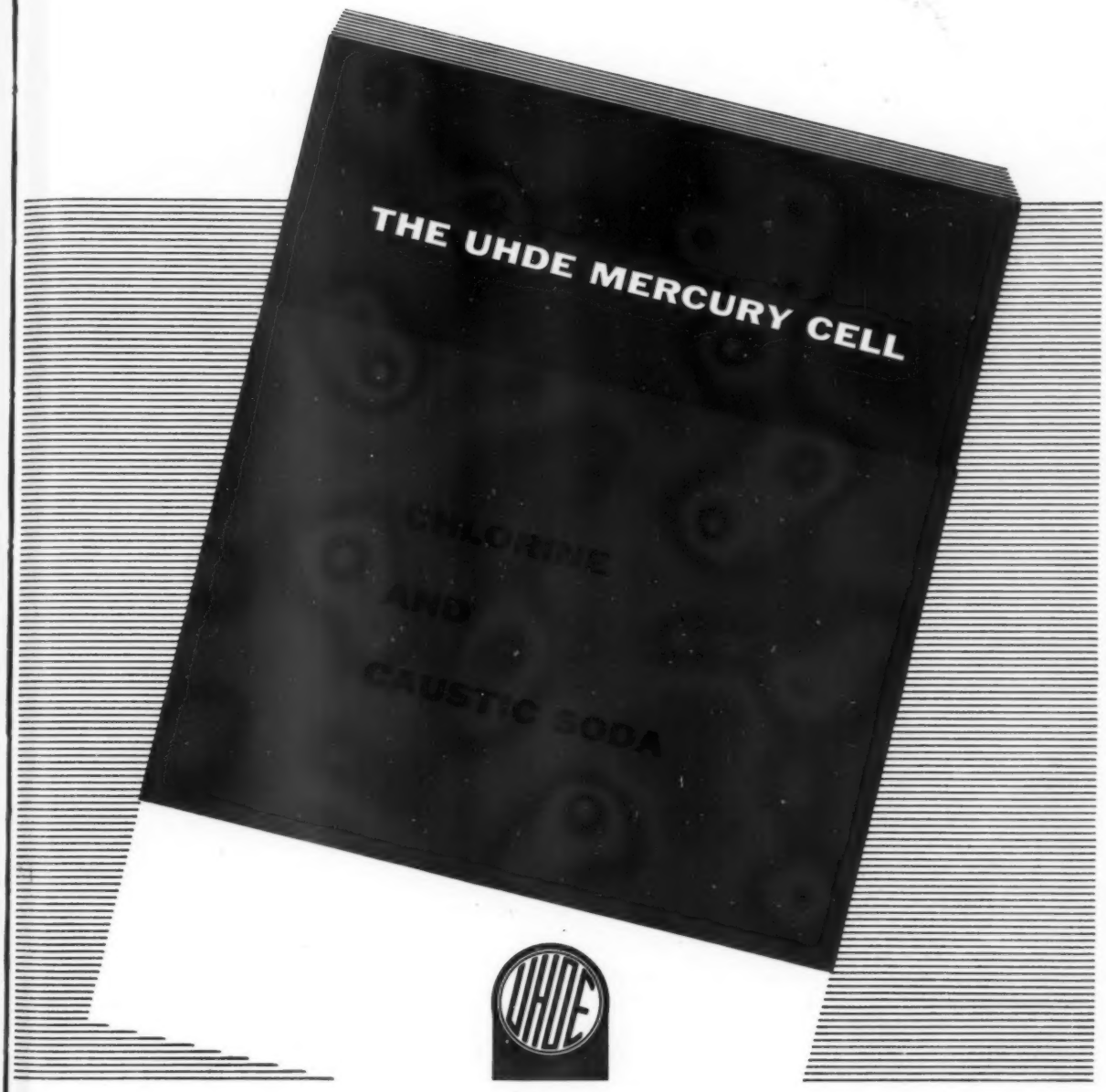
The Massachusetts Institute of Technology because of the high quality of the education given its students, its effective research work for aiding America in peace as well as in war, and the high character of its governing body and academic staff qualifies as an institution for serving our American ideals for the present and in the years to come.

But the search, the finding, and the anticipated accomplishments are not enough; for without the properly-worded record, man's plans for the future may go awry. Hence the prophet's importuning, "— give now," should be heeded. The giving need not be an immediate physical transaction, for written directions replace the spoken word when the speaker is no longer present, and a donor can frequently make by will a gift which is larger than he can make while living. Truly, *"it is well to give when asked, but it is better to give unasked, through understanding."*

A booklet "Gifts by Will," outlining different forms of bequests to M.I.T., is available to you or to your attorney by writing to:

Director of Development
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

* "The Prophet" by Kahlil Gibran



Further information concerning the Uhde Mercury Cell may be obtained from

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PLANT DESIGN

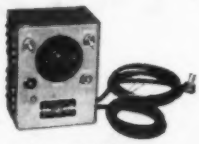
HOW Variac® MOTOR SPEED CONTROLS HELP KEEP THE SKY IN PLACE

Photograph Courtesy the Museum of Science, Boston

The nation's newest and most advanced planetarium at the Museum of Science in Boston provides visitors with the most realistic star show yet devised by man. Designed and developed by the Korkosz brothers of Springfield, Massachusetts, the projector is capable of reproducing 9,600 first- to sixth-magnitude stars, each correct in brightness to one-tenth magnitude.* Viewers see the stars just as they appear out-of-doors, even to their familiar twinkle.

G-R Variac Motor Speed Controls position the massive three-ton projector unerringly. In this way, the sky can be adjusted to appear as seen from any spot on earth and at any time of day. Variac Motor Speed Controls were picked for this application for a number of reasons: They allow the motor to deliver maximum torque at any speed. Effective filtering of ripple currents by the Control prevents torque pulsations in the motor's output. High starting torque permits quick motor starts even under full load conditions. The Control uses no electronic tubes, insuring instant warmup and minimum maintenance. The motor can be stopped or reversed with one switch . . . dynamic braking is standard on all controls above 1/15 hp. Good regulation plus the use of a Variac continuously-adjustable autotransformer in the control make for wide-range and smo-o-o-th speed variation.

**Intensity controlled by Variac® continuously-adjustable autotransformers.*



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1/15 hp capacity, **$85**

Type 1701-AKW
basic model 1/15 hp capacity, **$72**

Ten models are available for controlling d-c motors from a-c lines. Ratings range from 1/15 hp to 3/4 hp. Choice of either cabinet model, or basic stripped-down design for use as original equipment by machinery manufacturers

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